TRANSACTIONS

OF THE

American Fisheries Society

SIXTY-FIRST ANNUAL MEETING

HOT SPRINGS, ARKANSAS

September 21, 22 and 23, 1931

Published Annually by the Society

1931

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THE AMERICAN FISHERIES SOCIETY

Organized 1870 **Incorporated 1910**

The Society was organized to promote the cause of fish culture; to gather and diffuse information of a scientific character and to unite and encourage those interested in fish culture and fisheries problems.

OFFICERS FOR 1930-1931

President .... E. LEE LECOMPTE, Baltimore, Md.
Vice-President .... JAMES A. RODD, Ottawa, Canada
Secretary-Treasurer .... *CARLOS AVERY, New York, N. Y.
Librarian .... JOHN W. TITCOMB, Hartford, Conn.

Vice-Presidents of Divisions

Fish Culture .... M. C. JAMES, Washington, D. C.
Aquatic Biology and Physic, W. J. K. HARKNESS, Toronto Can.
Commercial Fishing .... CLARENCE BIRDSEYE, Gloucester, Mass.
Angling .... FRED A. WESTERMAN, Lansing, Mich.
Protection and Legislation .... I. T. QUINN, Montgomery, Ala.

OFFICERS FOR 1931-1932 †

President .... JAMES A. RODD, Ottawa, Canada
Vice-President .... H. S. DAVIS, Washington, D. C.
Secretary-Treasurer .... SETH GORDON, Washington, D. C.
Librarian .... JOHN W. TITCOMB, Hartford, Conn.

Vice-Presidents of Divisions

Fish Culture .... G. C. LEACH, Washington, D. C.
Aquatic Biology and Physics .... A. H. WIEBE, Fairport, Iowa
Commercial Fishing .... N. B. SCOFIELD, San Francisco, Calif.
Protection and Legislation, TALBOTT DENMEAD, Baltimore, Md.
Angling .... I. T. QUINN, Montgomery, Ala.

*** Died October 5, 1930. Succeeded by Seth Gordon, Washington, D. C.**

† For street addresses see membership list.

Executive Committee

FRED A. WESTERMAN, *Chairman*	Lansing, Mich.
CLARENCE BIRDSEYE	Gloucester, Mass.
LEE MILES	Little Rock, Ark.
THADDEUS SURBER	St. Paul, Minn.
C. F. CULLER	La Crosse, Wis.
T. H. LANGLOIS	Columbus, Ohio
BURNIE MAUREK	Sanish, N. Da.

Committee on Foreign Relations

HENRY O'MALLEY	Washington, D. C.
A. G. HUNTSMAN	Toronto, Canada
FREDERIC C. WALCOTT	Norfolk, Conn.
JUDSON L. WICKS	Minneapolis, Minn.
W. F. THOMPSON	Seattle, Wash.

Committee on Relations with Foreign and State Governments

LEWIS RADCLIFFE	Washington, D. C.
JOHN VAN OOSTEN	Ann Arbor, Mich.
CHARLES R. POLLOCK	Seattle, Wash.
JOHN P. BABCOCK	Victoria, B. C., Canada
C. C. WOODWARD	Tallahassee, Fla.
EMMELINE MOORE	Albany, N. Y.

Committee on Publications

JOHN W. TITCOMB, *Chairman*	Hartford, Conn.
DAVID L. BELDING	Boston, Mass.
GEO. C. EMBODY	Ithaca, N. Y.
H. S. DAVIS	Washington, D. C.

Presidents' Terms of Service and Places of Meeting

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The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for a period shown opposite their names, but they presided at the subsequent meeting.

1.	William Clift	1870-1872	New York, N. Y.
2.	William Clift	1872-1873	Albany, N. Y.
3.	William Clift	1873-1874	New York, N. Y.
4.	Robert B. Roosevelt	1874-1875	New York, N. Y.
5.	Robert B. Roosevelt	1875-1876	New York, N. Y.
6.	Robert B. Roosevelt	1876-1877*	New York, N. Y.
7.	Robert B. Roosevelt	1877-1878	New York, N. Y.
8.	Robert B. Roosevelt	1878-1879	New York, N. Y.
9.	Robert B. Roosevelt	1879-1880	New York, N. Y.
10.	Robert B. Roosevelt	1880-1881	New York, N. Y.
11.	Robert B. Roosevelt	1881-1882	New York, N. Y.
12.	George Shepard Page	1882-1883	New York, N. Y.
13.	James Benkard	1883-1884	New York, N. Y.
14.	Theodore Lyman	1884-1885	Washington, D. C.
15.	Marshall McDonald	1885-1886	Washington, D. C.
16.	W. M. Hudson	1886-1887	Chicago, Ill.
17.	William L. May	1887-1888	Washington, D. C.
18.	John Bissell	1888-1889	Detroit, Mich.
19.	Eugene G. Blackford	1889-1890	Philadelphia, Pa.
20.	Eugene G. Blackford	1890-1891	Put-in-Bay, Ohio
21.	James A. Henshall	1891-1892	Washington, D. C.
22.	Herschel Whitaker	1892-1893	New York, N. Y.
23.	Henry C. Ford	1893-1894	Chicago, Ill.
24.	William L. May	1894-1895	Philadelphia, Pa.
25.	L. D. Huntington	1895-1896	New York, N. Y.
26.	Herschel Whitaker	1896-1897	New York, N. Y.
27.	William L. May	1897-1898	Detroit, Mich.
28.	George F. Peabody	1898-1899	Omaha, Nebr.
29.	John W. Titcomb	1899-1900	Niagara Falls, N. Y.
30.	F. B. Dickerson	1900-1901	Woods Hole, Mass.
31.	E. E. Bryant	1901-1902	Milwaukee, Wis.
32.	George M. Bowers	1902-1903	Put-in-Bay, Ohio

*A special meeting was held at the Centennial Grounds, Philadelphia, Pa., October 6 and 7, 1876.

33.	Frank N. Clark	1903-1904	Woods Hole, Mass.
34.	Henry T. Root	1904-1905	Atlantic City, N. J.
35.	C. D. Joslyn	1905-1906	White Sulphur Springs, W.Va
36.	E. A. Birge	1906-1907	Grand Rapids, Mich.
37.	Hugh M. Smith	1907-1908	Erie, Pa.
38.	Tarleton H. Bean	1908-1909	Washington, D. C.
39.	Seymour Bower	1909-1910	Toledo, Ohio
40.	William E. Meehan	1910-1911	New York, N. Y.
41.	S. F. Fullerton	1911-1912	St. Louis, Mo.
42.	Charles H. Townsend	1912-1913	Denver, Colo.
43.	Henry B. Ward	1913-1914	Boston, Mass.
44.	Daniel B. Fearing	1914-1915	Washington, D. C.
45.	Jacob Reighard	1915-1916	San Francisco, Calif.
46.	George W. Field	1916-1917	New Orleans, La.
47.	Henry O'Malley	1917-1918	St. Paul, Minn.
48.	M. L. Alexander	1918-1919	New York, N. Y.
49.	Carlos Avery	1919-1920	Louisville, Ky.
50.	Nathan R. Buller	1920-1921	Ottawa, Canada
51.	William E. Barber	1921-1922	Allentown, Pa.
52.	Glen C. Leach	1922-1923	Madison, Wis.
53.	George S. Embody	1923-1924	St. Louis, Mo.
54.	Eben W. Cobb	1924-1925	Quebec, Canada
55.	Charles O. Hayford	1925-1926	Denver, Colo.
56.	John W. Titcomb	1926-1927	Mobile, Ala.
57.	Emmeline Moore	1927-1928	Hartford, Conn.
58.	C. F. Culler	1928-1929	Seattle, Wash.
59.	David L. Belding	1929-1930	Minneapolis, Minn.
60.	E. Lee LeCompte	1930-1931	Toronto, Ontario
61.	James A. Rodd	1931-1932	Hot Springs, Arkansas

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APPENDIX

PART I

BUSINESS SESSIONS

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TRANSACTIONS
of the
AMERICAN FISHERIES SOCIETY
SIXTY-FIRST ANNUAL MEETING
at
Hot Springs, Arkansas
September 21, 22, and 23, 1931

The Sixty-first Annual Meeting of the American Fisheries Society was held at the Arlington Hotel, Hot Springs, Arkansas, September 21, 22, and 23, 1931

REGISTERED ATTENDANCE

Aldridge, A. D., Supt. of Fish Propagation, Tulsa, Okla.
Amsler, Guy, Secretary, Game and Fish Commission, Little Rock, Ark.
Ball, John N., E. I. du Pont de Nemours and Co., Madison Wis.
Barmeier, Harry, U. S. Game Protector, St. Louis, Mo.
Bell, Dwight, Game and Fish Commission, Ardmore, Okla.
Berg, George, Supt. of Hatcheries, Indianapolis, Ind.
Britton, B. R., U. S. Game Protector, New Mexico.
Brown, James, Fish and Game Dept., Montpelier, Vermont.
Brown, Dell, Bureau of Fisheries, Mammoth Springs, Ark.
Burleson, Frank, Fish Dept, Medicine Park, Okla.
Burr, J. G., Director of Research and Education, Texas Game and Fish Commission, Austin, Texas
Burr, Mrs. J. G., Austin, Texas
Carrigan, P. B., Hope, Ark.
Chappell, Game Warden, Piggott, Ark.
Charlton, Marquis, U. S. Game Protector, Columbus, Ohio.
Chute, W. H., Director of Shedd Aquarium, Chicago, Ill.
Clark, I. P., Heavener, Okla.
Clarkson, Frank, U. S. Game Protector, Houston, Texas.
Cobb, Eben W., Field Supervisor, State Warden Fisheries, Hartford, Conn.
Cook, A. B., Jr., Field Supt. Department of Conservation Michigan, Lansing, Mich.
Courington, M. L., Heavener, Okla.
Cowanloch, James Nelson, Chief Biologist, Bureau of Scientific Research, New Orleans, La.
Creech, Stephen, Peoria, Ill.
Crosby, Caroline, Minneapolis, Minn.
Crossley, Stephen B., Federal Reservation Protector, Manilla, Ark.
Culler, C. F., U. S. Bureau of Fisheries, LaCrosse, Wis.
Cummings, Otto, Game Warden of Blytheville, Blytheville, Ark.
Davis, Hosea L., Game and Fish Commission, Mammoth Springs, Ark.
Davis, H. S., U. S. Bureau of Fisheries, Washington, D. C.
Davis, Henry P., E. I. du Pont de Nemours and Co., Memphis, Tenn.
Dauenhauer, J. B., Jr., Director Enforcement & Fisheries Department of Conservation, New Orleans, La.
Deaton, W. N., Arkansas Game and Fish Commission, Little Rock, Ark.
Denmead, Talbott, Law Enforcement Officer, U. S. Bureau of Fisheries, Washington, D. C.
Duvall, R. E., Dept. of Conservation, Springfield, Ill.
Ebel, Walter, Hot Springs, Ark.
Farley, John L., Executive Officer, Division of Fish and Game, California.
Flynn, James, Controller of Game Wardens, Indianapolis, Ind.
Gordon, Seth, Secretary, American Fisheries Society, President, American Game Association, Washington, D. C.
Grater, C. B., Supt. of Texas Hatcheries.
Gray, A. E., U. S. Biological Survey, Oklahoma City, Okla.
Gurley, Ira M., Game & Fish Commission, Little Rock, Ark.
Hazzard, A. S., Asst. Biologist Bureau of Fisheries, Utah.
Hamilton, Scott D., Hot Springs, Ark.
Heyward, A. C., E. I. du Pont de Nemours and Co., Columbia, South Carolina.
Hill, F. J., State Secretary, Izaak Walton League, Oklahoma City, Okla.
Hogan, Joe, State Fish Culturist, Lonoke, Ark.
Hoofnagle, G. W., Supt. Orangeburg, S. C.
Hoofnagle, Mrs. G. W., Orangeburg, S. C.
Hubbs, Carl L., Director of Fisheries Institute, Ann Arbor, Mich.
Hubbs, Mrs. Carl, Ann Arbor, Mich.
Hubbs, Clark, Ann Arbor, Mich.

Hubbs, Earl, Ann Arbor, Mich.
Hubbs, Francis, Ann Arbor, Mich.
James, M. C., Bureau of Fisheries, Washington, D. C.
Johnson, Floyd A., U. S. Game Protector, New Orleans, La.
Kinkead, M. D., Pres., Garland County Fish & Game Protective Assn., Hot Springs, Ark.
Knecht, Roy, Heavener, Okla.
Lacefield, W. L., Game Warden, Arkansas Game and Fish Commission, Forrest City, Ark.
Laird, James A., Supt. of Fisheries, South Side Sportmen's Club, Oakdale, Long Island, N. Y.
Langlois, T. H., Chief of Bureau of Fisheries, Columbus, Ohio.
LeCompte, E. Lee, President American Fisheries Society, State Game Warden of Maryland, Baltimore, Md.
Leopold, Aldo, Madison, Wisconsin.
McGrew, J. O., Game Warden, Arkansas Game and Fish Commission, Poplar Grove, Ark.
McLaughlin, Mayor Leo P., Hot Springs, Ark.
McMurtrey, M. S., State Game & Fish Dept. Supt. of, Oklahoma City, Okla.
Manning, Arthur, Game Dept. of Oklahoma, Medicine Park, Okla.
Maurek, B. W., Commissioner, Bismarck, North Dakota.
Meredith, C. J., Kentucky Game and Fish Commission, Frankfort, Ky.
Merovka, L. J., U. S. Game Protector, Memphis, Tenn.
Miles, Lee, Arkansas Game and Fish Commission, Little Rock, Ark.
Mobley, Ben E., State Game Warden, Game and Fish Dept., Oklahoma City, Okla.
Montgomery, Van H., Supt. Game Reserve, Bartlesville, Okla.
Montgomery, Mrs. Van H., Bartlesville, Okla.
Moore, Dr. Emmeline, State Conservation Dept., Albany, N. Y.
Mowery, F. C., Hot Springs, Ark.
Murphree, J. M., Supt. State Fish Hatcheries, Durant, Okla.
Neelly, Harry, Fish and Game Commissioner, Searcy, Ark.
Nix, W. A., Supt. Fish Hatcheries, Heavener, Okla.
Nix, Mrs. W. A., Heavener, Okla.
Ormsby, F. E., Ranger, Okla. Game and Fish Commission, Ardmore, Okla.
Otterson, John, E. I. du Pont de Nemours and Co., Wilmington, Delaware.
Perdue, Catherine, Little Rock, Ark.
Phillips, J. L., Lufkin, Texas.
Powell, A. M., Supt., Maryland State Hatcheries, Baltimore, Md.
Riddick, G. M., U. S. Game Protector, Little Rock, Ark.
Rodd, J. A., Director of Fish Culture, Ottawa, Canada.
Ross, John H., Missouri State Game and Fish Commission, Jefferson City, Mo.
Ross, Mrs. John H., Jefferson City, Mo.
Shaver, B. J., U. S. Game Protector, St. Paul, Minn.
Shirts, Walter, Supt. of Fish and Game, Indianapolis, Ind.
Stewart, William D., Minnesota State Game and Fish Commission, St. Paul, Minn.
Stroud, A. T., Conservationist, Virginia.
Surber, Eugene W., Special Investigator, U. S. Bureau of Fisheries, Trempealeau, Wis.
Surber, T., Game and Fish Dept. Minnesota, St. Paul, Minn.
Swain, Pat, Game Warden, Hot Springs, Ark.
Tilden, Miss Josephine E., University of Minnesota, Minneapolis, Minn.
Titcomb, John W., Supt. of Fish and Game, Hartford, Conn.
Viosca, Percy, Jr., Biologist, Southern Biological Society, New Orleans, La.
Viosca, Mrs. Percy, Jr., New Orleans, La.
Viosca, Cranford, New Orleans, La.
Viosca, Yvonne, New Orleans, La.
Von Bayer, A. H., Baltimore, Md.
Von Bayer, Mrs. A. H., Baltimore, Md.
Walker, C. V., Little Rock, Ark.
Walker, Mrs. C. V., Little Rock, Ark.
Ward, Miss Fern, University of Minnesota, Minneapolis, Minn.
Ward, L. C., Oklahoma.
Webster, B. O., Supt. of Fisheries, Madison, Wis.
Westerman, Fred A., Supt. Fish Hatcheries, Lansing, Mich.
Westmoreland, E. W., Heavener, Okla.
Wickliff, E. L., Division of Conservation, Columbus, Ohio.
White, E. F. G., E. I. du Pont de Nemours and Co., Ottawa, Canada.
Wiebe, A. H., Scientific Investigator in Fish Culture, Fairport, Iowa.
Wilkins, J. E., Assistant Game Warden, Oklahoma City, Okla.
Woodson, M. E., Memphis, Tenn.
Woodson, Mrs. M. E., Memphis, Tenn.
Young, E. C., Ottawa, Canada.
Young, John H., Heavener, Okla.

BUSINESS SESSIONS

The meeting was called to order by president E. Lee Le Compte at 10:00 A. M. Monday morning, September 21, 1931.

Addresses of welcome were delivered by Hon. Leo McLaughlin, mayor of Hot Springs, and by Judge Lee Miles, Chairman of the Game and Fish Commission of Arkansas. Acknowledgment of these addresses of welcome was made by the President.

REPORT OF THE SECRETARY-TREASURER

For the year 1930-31

SETH GORDON

Your Secretary-Treasurer has done his best to fill the gap created by the untimely death of our co-worker and loyal friend, Carlos Avery. As was to be expected, there were many things to learn about our Society, and its method of operation. Fortunately it was my pleasure to have the assistance of the same efficient secretary as had Mr. Avery, and this made it possible to carry on the work of the Society without interruption.

While there was no special campaign for members during the year, there were fifty-six new members added during the year, twenty-four resigned, and twelve died, leaving a net gain of twenty members.

The year previous there were fifty-five new members, eleven resigned, eight died, and forty-three were dropped for non-payment of dues.

During the past year we did not drop members for the non-payment of dues, but a number of them are subject to such action and the first step to that end has been taken.

There has in the past been some confusion in the minds of members concerning the period for which they have paid dues, as it has been the practice of the Society to collect dues for the year beginning with the date of the annual meeting. Often no effort was made to collect dues from those not attending the meetings until a few weeks before the printed transactions were ready for distribution.

After giving the matter some study your officers and executive committee have agreed that in the future the membership year of the Society run from July 1 to June 30 inclusive, thereby fixing a definite date for the expiration of all memberships. Memberships paid for this annual meeting, and up to and including June 30 next, will expire on July 1, 1932. Receipts for dues in the future will read accordingly.

The printed transactions of the Society are sent only to those members who have paid their dues.

The transactions for the 1930 meeting were quite voluminous and expensive because of the large number of illustrations used, but the editing committee did a splendid job under the direction of Doctor Belding and the volume is an excellent one.

The wisdom of again using part of the income from the Society's permanent fund to offer prizes for the best contributions of the year to the advancement of fish culture and research, or to prepare and distribute abstracts of important papers and articles on the subjects in which the Society is interested, has been given further consideration during the year. At a meeting of the officers and executive committee it was decided to appoint a committee consisting of Messrs. John W. Titcomb, H. S. Davis and Thaddeus Surber to study the matter and report with recommendations at the 1932 meeting.

There has been an increase in the permanent fund of the Society during the year of $288.44 from interest, and the fund now stands at $4,434.71.

Due to the fact that some of the dues have already been paid in for the 1931-32 membership year, the balance in the treasury to the credit of the general fund is now $1,279.59 as against $950.64 at the time of the last annual meeting.

The fiscal transactions of the Society for the year were as follows:

TREASURER'S REPORT

General Fund

RECEIPTS

Balance on hand at meeting of 1930		$950.64
Annual Dues		
Individuals and Libraries:		
For the year 1928	$12.00	
1929	45.00	
1930	1,227.12	
1931	501.65	
Clubs and Dealers:		
For the year 1928	5.00	
1929	10.00	
1930	140.03	
1931	90.00	
1932	5.00	
State Memberships:		
For the year 1930	160.00	
1931	40.00	
Sale of Separates:		
For the year 1927	5.93	
1929	99.34	
1930	190.78	
Sale of Transactions	234.59	
Sale of Index-Catalogue	5.00	
Refund—premium on bond of Carlos Avery	2.50	
American Game Assn.—membership Wm. Keil	1.00	
Returned checks redeposited		
Richard E. Follett	3.00	
J. L. Phillips	3.00	
J. D. Reid	3.00	2,783.94
		$3,734.58

DISBURSEMENTS

	Voucher No.		
1930 Meeting, Toronto, Canada			
Reporting Proceedings of	58	$175.00	$175.00
Transactions, 1929, vol. 59			
Indexing	56	28.08	28.08
Transactions, 1930, vol. 60			
Printing, mailing, postage	68	1,000.00	
" " "	70	529.16	
Indexing	72	30.60	

Reprints	74	283.51	
"	81	6.25	1,849.52
Postage, express, telegrams & miscellaneous			
Librarian's office	52	1.13	
" "	62	10.00	
" "	73	3.89	
" "	76	1.17	
" "	80	5.00	
Secretary-Treasurer's office	57	10.94	
" " "	59	7.86	
" " "	63	11.23	
" " "	67	9.59	
" " "	69	10.80	
" " "	75	25.05	
" " "	77	10.60	107.26
Premium on treasurers' bonds			
Carlos Avery	53	2.50	
Seth Gordon	66	2.50	5.00
Printing, stationery, etc	55	31.97	
" " "	64	8.00	
" " "	71	10.10	
" " "	79	18.00	
" " "	84	11.00	79.07
Refund—American Game Assn.	60	1.00	
" G. Sundbeck	82	.50	1.50
File cabinet	65	23.47	23.47
Folders and guides	78	7.00	7.00
Reprints, 1927	61	4.14	4.14
Clerical services, Secretary-Treasurer's Office, Sept. 1930-Sept. 1931	83	150.00	150.00
Exchange on checks (vouchers attached to bank statements)		3.95	3.95
Checks returned by bank			
Spencer Otis (insufficient funds)		3.00	
J. D. Reid (endorsement)		3.00	
R. G. Fortney (bank closed)		6.00	
R. E. Follett (post dated)		3.00	
J. L. Phillips (endorsement)		3.00	
F. G. Landstreet (deceased)		3.00	21.00
			$2,454.99

Receipts—General Fund	$3,734.58	
Disbursements—General Fund	2,454.99	
Balance on hand September 12, 1931		$1,279.59

PERMANENT FUND

Cash balance on hand, 1930 meeting	$206.27	
Interest on Savings Account received (bank)	8.44	
Interest on Trust Company Certificates	220.00	
Total in Savings Account		$434.71
Certificates Title Guarantee & Trust Co.		4,000.00
Total		$4,434.71

The report of the Secretary-Treasurer was received and referred to the Auditing Committee. Upon the approval of the committee it was later accepted by the Society.

REPORT OF LIBRARIAN

JOHN W. TITCOMB

The office of Librarian was created in order that there might be a place for the large number of publications of the Society. They had been moved from one place to another with each change in the office of Secretary because there was no regular storage place for them.

We now have in a secure place the following nucleus to two complete sets:

Year	Number of Copies
1876	2
1884	1
1885	2
1886	1
1888	1
1889	1
1890	1
1891	1
1892	1
1893	1
1894	1
1895	2
1896	2
1897	2
1898	2
1899	2
1900	2
1901	2
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1912	2
1913	2
1914	2
1915	2
1916	2
1917	2
1918	2
1919	2
1920	2
1921	2
1922	2
1923	2
1924	2
1925	2
1926	2

1927	2
1928	2
1929	2
1930	2

These are intended as the permanent property of the Society, unless it may be deemed wise to spare one copy when such an institution as the Congressional Library at Washington wishes to complete a set.

Information regarding volumes available can be obtained by writing either the Librarian or the Secretary of the Society.

Every fish culturist should have a set of these proceedings, or at least, the later issues—say from 1900 to date. The earlier copies are more suitable for collectors than for those who really look for up-to-date information.

It is suggested that when investigators are looking up anything which may have been published, they call at their local library for the Index of the Transactions of the Society. This Index was published a year ago, giving a list of all the papers by title and by authors. It is especially valuable to anyone who wants to prepare a paper, because it obviates repeating material which may have been given in an earlier issue. If the library does not contain an Index, inquiry for one may lead to a copy being secured.

Our last inventory showed one hundred and ninety-one copies in paper covers, which sell at $4.00 each, and six hundred and twelve in cloth at $5.00 each. The indexing of these publications down to 1929 was a heavy and expensive task. From 1929 on each publication will have a classified index prepared by a professional card catalogist.

I want to urge not only that you ask the libraries for an opportunity to see the Index, but that you call for any particular volume of the Transactions that you may be interested in and so give the library to understand that there is a demand for such publications. To undertake to circularize all the libraries of the country with a view to disposing of these indices would be quite expensive.

Many states cannot under their laws join the Society. Many such states can buy volumes of the Transactions and distribute them to their fish culturists. I feel very strongly that every fish culturist should have a copy of all the later editions and be connected with the Society either as a member or through obtaining the publication. It is really the only medium through which one can keep up-to-date in the fish cultural matters and in touch with the scientific investigations and conclusions that relate thereto.

If the states which can not be identified with the Society as members would buy copies of the Transactions it would help our treasury, but it would help their employees far more, and that is the main point I am trying to get at—to get them to work. I urge every member to hold

on to his copy of the Annual Transactions, because they are becoming more valuable as time goes on.

There are editions of these Transactions for which I would not hesitate to pay ten dollars apiece.

The library has no printed publications of the Transactions until 1876 and lacks copies for its own files covering the years:

1877
1878
1879
1880
1881
1882
1883
1887
1902
1903
1905

The Librarian would like to secure copies of all of the above for the permanent files of the Society and in addition, it would be advantageous to have copies available to complete sets for libraries. In addition to those needed for the permanent files there are no copies available for distribution or sale covering the years 1899 and 1900. We have an ample number of copies of the Transactions covering all other years to meet the demands of those who are collecting sets or want to refer to some individual publication.

We may even have to go to the expense of reprinting a few of the editions in order to meet the demand; I am merely waiting until the number applied for gets a little larger.

REPORTS OF VICE-PRESIDENTS OF DIVISIONS

REPORT OF THE DIVISION OF FISH CULTURE

M. C. James

In submitting a report as Vice President for the Division of Fish Culture of the Society, it is not my intention to dwell upon inventions, discoveries, adaptations, and investigation in technical methods of propagating fish.

The annual meeting of the Society provides a forum where these advances may be announced and explained by their originators. It would seem of greater importance and interest to the membership to attempt to show the magnitude and scope of the science or industry in which the greater majority are engaged. In other words, I would like to demon-

strate just how important fish culturists and their accomplishments are from a national standpoint. Necessarily, such a discussion must be of a statistical nature; but unfortunately no data can be secured which will give absolute statistical accuracy to any figures that may be cited. As many of you are aware, the various states utilize different dates for closing their business years, and the figures for the fish cultural operations do not therefore represent the same calendar period, although they represent the same extent of time, namely, one year.

These figures can consequently be cited only as approximations and indications of what a normal year represents in the way of hatchery output, employment of personnel, expenditures, etc., for the entire country. I also regret that further discrepancy appears in the following figures, due to the fact that at the time of compiling them five states had not as yet sent in their summary of fish cultural operations.

The figures were received after June 30, and represent the year ending at that date, or the latest complete year prior to that period. Figures covering the various states were furnished by the states themselves in response to request from the Bureau of Fisheries. I therefore desire to again emphasize that the following data are not precise and absolute but rather are an approximation representing the most complete compilation which can be secured under existing practices.

Of primary importance, of course, is the total output or production of all of the hatcheries operated in the United States and Alaska.

Total hatchery output:

States (incomplete)	4,046,954,621
Federal	7,121,805,700
Total	11,168,760,321

eggs, fry, and fish of all sizes.

No data covering the operations of private hatcheries during this period are on record. However, during 1929 Mr. C. R. Lucas of the Bureau of Fisheries conducted a survey of this enterprise, and for the benefit of those who are not too fussy about the accuracy of their figures I will include the findings of this survey as an indication of the nationwide fish cultural activities in what might be considered a normal year.

Furthermore, in referring to private hatcheries no data for the hatcheries operated by sportsmen's clubs for the stocking of preserves or other strictly private waters are included. The bureau's figures for private hatcheries refer only to those which are conducted as an active public commercial enterprise. It is quite probable that there are many clubs and numerous individuals who are raising a few trout for maintenance of fishing in their own waters or purely for their own amusement. In fact, state license figures show that there are many more licenses issued for the propagation of fish than there are establishments operated on a

commercial basis. However, no data are available as to the significance of the establishments in this group and, in view of the belief that their output, investment, and personnel are limited, it is believed that omission from this chronicle will not constitute a serious defect.

These private agencies produced 272,875,930 eggs and fish in 1929, which would give an aggregate sum for a sample year of 11,441,636,251. Apparently, fish culturists are second only to astronomers in the ease with which they handle voluminous figures. It appears desirable to break down these totals to show the relative importance of some of the chief species.

For trout the report is as follows:

State (incomplete)	204,317,705
Federal	62,507,500
Total	266,825,205

eggs and fish.

The greater difficulty experienced in the propagation of bass is well illustrated in the figures for this species:

State (incomplete)	11,875,982
Federal	4,274,700
Total	16,150,682

If you again wish to consider the 1929 figures of the commercial hatcheries in connection with the above summary for a later year, add 270,860,144 trout, or a total about equivalent to the combined Federal and state production, resulting in an aggregate of 537,000,000 in round numbers. The bass added by private hatcheries under the above conditions would be about 680,000, keeping the yearly total still under 17 million.

It is, of course, unnecessary to point out to this organization that by far the greater proportion of this tremendous hatchery production is credited to commercial forms which are extremely prolific, and which are distributed in the fry stage.

The output of commercial species, which includes the marine varieties, such as cod, haddock, whitefish, lake herring, commercial salmons, pike perch, carp, etc., is as follows:

State	3,423,319,302
Federal	6,897,486,500
Total	10,320,805,802

I do not recall offhand which agency was responsible for the final two specimens cited. The balance covered by the difference between this

total and that cited at the start of the report represents other game fishes and miscellaneous forms which include many and diverse species in various catagories in the different parts of the country, and involves too great complications to attempt to straighten them out.

Of secondary importance is the number of hatcheries, substations, and other auxiliaries responsible for this output, and these are as follows:

State	355
Federal	85
Total	440

In 1929 there were 133 private commercial hatcheries, and since the number has apparently not increased greatly we may be justified in adding this to the above, giving, therefore, a total of 573 establishments in this country engaged in the rearing and hatching of fish.

As for the presonnel required to operate these establishments, we find that the Federal hatcheries employed 297 and the states 1,185 men, giving a total of 1,482 individuals, comprising the guild to which we belong. Again bringing in the figures for the private hatcheries for 1929, we find that they employed 262 persons exclusive of the proprietors; so that there are about 1,744 individuals in this country who, for reasons best known to themselves, are endeavoring to make an honest living by raising fish. Incidentally, it is of further interest to note that the employees of the private hatcheries received $277,538 in salaries, which gives each and every one an annual average income of approximately $1,050. Remembering this figure, you will understand why it is proper to refer to their efforts to earn a living, rather than to gain any luxuries.

As for the expenditures of the tax payers' money required for the support of this small regiment of men and the establishments at which they work, we note that the states expended $3,315,909.21, while the Federal Government was disbursing some $950,000. This aggregates in the neighborhood of four and one-fourth million. Interesting conclusions might be reached by correlating these expenditures with the total output of the hatcheries, and with expenditures for other forms of conservation.

It is realized, however, that I have already been wallowing too eagerly in a mass of figures and statistics and I will leave the foregoing to your own computations. It may be interesting to add, however, that reports on licenses show that 4,948,415 individuals took out licenses which authorized them to fish or to hunt and fish. Numerous anglers of the farm-boy category, as well as other groups, are not required to take out licenses so that I feel safe in assuming that at least 5,000,000 Americans had designs on our game fish population during the past year. Furthermore, the above licenses paid in $6,999,929.77 for the privilege,

which indicates that they are more than defraying the cost of the hatcheries operated for their benefit and for the perpetuation of commercial fisheries.

I do not know whether the strings of digits which have been set before you will occasion a thrill of pride or will give rise to some other sentiment. They do represent an earnest effort to present to you a bird's-eye view of the scope and magnitude of the artificial propagation of fish in the United States at the present time.

REPORT OF THE DIVISION OF ANGLING

FRED A. WESTERMAN

The angler occupies a highly important and strategic position in the general scheme of conservation. In point of mere numbers, it is probably no exaggeration to say that fifty percent or more of our adult population is interested in some form of angling. No topic of conversation will more quickly gain for one an interested and awakened audience than a discussion of last season's fishing trip on the favorite trout stream or the cool limpid lake. Recalling the memories of such trips when the snow is piled high around the hearth is one of the pleasures we cannot share with our southern friends, but then I understand they may fish about 365 days in the year.

It then follows that this great throng, who represents the brawn and the sinew, the men in high places and in low, is in a large degree responsible for the progress which we are making in regulating, maintaining and conserving our fisheries.

I just wonder sometimes how many of the policies, with which fish conservation has surrounded itself, had their inception as a result of some angler's disturbance, annoyance or concern with conditions encountered on a sojourn to his favorite fishing retreat.

It is the angler who searched out the remotest outposts of civilization in his quest for finny prizes and in his wake has followed the lumberman, the miner, the agriculturist, manufacturer, towns and cities with their attendant and constantly changing conflicting problems for the scientist, and for the practical fish culturist. In the face of all this the angler visualizes rivers, streams and lakes undefiled, pure as he first found them and our problem as a society is very largely one of preventing further despoilation of our waters, as well as encouraging the improvement and restoration of waters already defiled. I believe that in the advancement of our fisheries program, we must concern ourselves in the future even more than in the past to insure that we have

suitable environments for fish, rather than with greatly increased production.

My faith in the economy of nature, when given a chance, is unbounded. We, in the several states and our Dominion neighbors, are all striving in various ways to meet these problems. What really matters is not so much how the job is done, but rather that it be done to the end that man, woman and child may perpetually enjoy in unstinted measure a heritage of clean lakes and clean streams.

I think I may say that the anglers of this continent stand behind the state, federal, provincial and dominion authorities charged with the administration of our fisheries and this Society one hundred per cent. Their opportunity for piscatorial pleasures is largely in your hands. I trust that our deliberations here will be another step in the progress made in the administration and conservation of our fishery resources with which we are all concerned.

REPORT OF THE DIVISION OF COMMERCIAL FISHING

CLARENCE BIRDSEYE

General Statistics

Since the last meeting of the Society the United States Bureau of Fisheries has published some very interesting figures of the commercial catch of fish in the United States by geographical sections during the year 1929. This is only the third time that the Bureau has made these figures available for all the geographical sections in the same year. Previous complete statistics were for the years 1880 and 1908. The total production in 1880 was 1,570,000,000 pounds valued at $40,000,000; in 1908, 1,893,000,000 pounds valued at $65,878,000; and in 1929, 2,915,000,000 pounds valued at $123,054,000. In the twenty-eight-year period from 1880 to 1908 the growth was 322,000,000 pounds valued at $25,900,000 while in the twenty-one-year period from 1908 to 1929 the increase has been very much greater, amounting to over 1,000,000,000 pounds in quantity and $57,176,000 in value.

The greatest increase has taken place in the New England, South Atlantic, Gulf and Pacific Coast States. The Middle Atlantic States have shown a steady decline in production while the Chesapeake, Mississippi and Great Lakes Fisheries have not much more than held their own. Although the Pacific Coast Fisheries showed a drop from 186,000,000 pounds in 1880 to 175,000,000 pounds in 1908, the subsequent increase has been tremendous, the catch in 1923 amounting to 405,000,000 pounds and in 1929 totaling 1,034,000,000 pounds. The above figures are exclusive of the 650,000,000 pound Alaskan catch in the year

1929 so that the total production of the United States and Alaska in that year was 3,567,270,000 pounds, which makes us the largest fish producing country in the world, eclipsing even China whose annual production is estimated at 3,000,000,000 pounds.

Relative Importance of the Several Species

According to the Bureau of Fisheries, for the year 1929 one hundred forty-eight species entered into the commercial catch in the United States. The accompanying Table No. 1 shows the production and value of the fifteen leading species. Haddock, cod, flounders, mackerel, shad, menhaden, oysters, clams and lobsters were caught in greatest abundance on the Atlantic Coast; while salmon, halibut, tuna, pilchards and sea herring were taken principally on the Pacific Coast. The Gulf Coast led only in the production of shrimp.

TABLE I

Production Commercial Fisheries 1929

Species	Production Pounds	Values	
Salmon (Including Alaska)	584,539,000	$20,464,000	W
Oysters	151,450,000	16,684,000	E
Haddock	261,258,000	9,142,000	E
Halibut	55,297,000	6,413,000	W
Shrimp	113,263,000	4,575,000	S
Pilchard	651,802,000	3,588,000	W
Cod	116,652,000	3,541,000	E
Lobsters	11,747,000	3,508,000	E
Flounders	75,329,000	3,479,000	E
Mackerel	122,094,000	3,277,000	E
Clams (hard)	8,128,000	2,530,000	E
Shad	17,234,000	2,468,000	E
Yellowfin (tuna)	37,399,000	2,200,000	W
Menhaden	393,405,000	2,148,000	E
Sea Herring	262,258,000	1,859,000	W & A

Packaged Fish

Probably the most dramatic features of the fish industry during the last decade has been the tremendous growth in the distribution of packaged dressed seafoods. In 1921 the production of fish fillets was about 50,000 pounds. In 1929, 85,000,000 pounds of fillets and other dressed fish were produced. In 1930 packaged fish production dropped back to a little over 80,000,000 pounds because of general economic conditions and competition from exceptionally low priced poultry and eggs. Inasmuch as the average yield of dressed fish from fish as landed by the vessels is only about 40 per cent, the 80,000,000 pounds of packaged product produced in 1930 represented the total of approximately 200,000,000 pounds of whole fish. Of the 1930 production 59,174,823 pounds or

69 per cent were marketed fresh; 22,216,130 pounds or 28 per cent were marketed frozen; and most of the remainder were smoked. Ninety-two per cent of the packaged fish was marketed in the form of fillets. Haddock comprised 78 per cent of the total output with cod a poor second, accounting for only 8 per cent of the total.

The growth of the packaged fish industry has been particularly significant in New England and New York where the greater part of the packaged product has been produced. The introduction of modern business methods has brought outside capital and personnel into the industry and has been responsible for the greatly increased progressiveness and effectiveness of the New England Fisheries in recent years. Concentrated dressing operations have led to greater improvements in the untilization of the eliminated waste for by-products and to high calibre laboratory research in several of the important, independent units of the industry. The United States Bureau of Fisheries has cooperated very effectively in industrializing the New England Fisheries and now maintains a laboratory at Gloucester from which the industry confidently expects much help.

The outstanding contribution to the fish industry in recent years has been the development of quick-freezing of the packaged product, which has resulted in taking seafoods out of the "perishable" foods class and making them available throughout the country during all periods of the year. Although the present industrial depression has slowed up the fish industry, as it has practically all others, the recession may be confidently regarded as only temporary, and in the future rapid progress may be expected.

Canada

Although Canada probably owns the most valuable fisheries in the Western Hemisphere, if not in the world, many of them are only partially developed. At the present time Canada produces between fifty and sixty million dollars worth of fishery products annually—a little less than half the value of those of the United States. Many people feel that the growth and modernization of the groundfish fisheries of eastern Canada have been unfortunately retarded by regulations practically prohibiting the use of trawlers. Canada, undoubtedly, has very important, undeveloped fisheries possibilities in her large northern interior lakes.

In 1930 the Pacific Coast of Canada produced 538,585,100 pounds and the Atlantic Coast 463,920,500 pounds of fishery products. The latter showed a decrease of 70,680,300 pounds while the former showed an increase of 12,717,200 pounds compared with the 1929 figures. The decrease on the Atlantic Coast was due to reduction in the herring and cod catch while the increase on the Pacific Coast was caused by a 65,000,000 pound increase in salmon production.

Prices were generally lower than in 1929 in practically all items during the year. However, the total value of the Canadian fisheries remained around $50,000,000.

The fisheries of Canada are closely identified with those of the United States. Practically all the commercial species of Canada are duplicated in the United States. Consequently, close cooperation should and does exist in regulating the contiguous fisheries of the two countries. This is particularly the case in the halibut, haddock and mackerel fisheries wherein scientific investigators from both countries not only cooperate, but commissions have been appointed which are jointly and severally studying the fisheries from biological and economic angles, not for the benefit of either country but for the good of the fisheries themselves.

REPORT OF THE DIVISION OF AQUATIC BIOLOGY AND PHYSICS

WILLIAM J. K. HARKNESS

The hydrobiologists of North America are being exceptionally favoured this year. Dr. Richard Woltereck of the University of Leipzig and the Biologisches Laboratorum Seeon (Chiemgau. Ob. Bayern), and editor of the International Review of Hydrobiology is spending the latter part of the summer and the autumn visiting American hydrobiologists at biological stations and universities.

While in North America Dr. Woltereck in addition to his informal visits is giving lectures dealing with various phases of hydrobiology such as Genetics and the biology of islands and lakes, shape, movement and stratification of plankton, and the present status of marine and fresh water biology in Europe. As a result of Professor Woltereck's visit and lectures we will gain first-hand knowledge of progress and methods of European limnologists.

It is of the utmost importance that investigators in different countries use standard equipment and work in harmonious understanding so that results of investigations will be comparable. Visits such as this, more than anything else bring about this desirable situation.

During July of this summer a Biological Conference met at Matamek, Saguenay Co, Quebec, Canada, to consider the phenomenon of periodic fluctuations in the abundance and scarcity of animals. This phenomenon is coming to be recognized as an established fact in the case of terrestrial organisms, such as the snowshoe rabbit and grouse. Evidence submitted by Dr. A. G. Huntsman and Prof. E. B. Phelps and Dr. D. L. Belding seemed to show that the same type of fluctuation is occurring in the Atlantic salmon of eastern Canada.

Fluctuations in fisheries may be brought about by exploitation, they may also occur naturally, but these natural fluctations may be obscured by fishing. A great effort should be put forth to collect data on any natural fluctuations which may make it possible to determine the underlying causes. The taking of fish should be regulated with all the available knowledge of these fluctuations in mind.

In connection with the question of fluctuations attention should be called to the special meeting held in Europe last year under the auspices of the International Council for the Exploration of the Sea at which the problem of fluctuations in the abundance of the various year classes of food fishes was considered. At this meeting Dr. Hjort, the chairman, suggested the setting up of an international biological organization for the regular observation of age distribution in the stocks of food fishes and the relative numerical strength of the year classes. Dr.Van Oosten has made a valuable contribution to such knowledge in his study of the ciscoes of Saginaw bay. This whole subject is one of such fundamental inportance that this association should take some action to encourage research in this field.

The pollution problem is still with us. Our knowledge of this subject advances slowly. Among pollutions there are three types: poisons directly toxic to fish, made innocuous by dilution; oil, at all times and places harmful; and domestic sewage, at first detrimental due to deoxygenating effects but following decomposition and complete oxygena tion, an excellent fertilizer.

This brings up the question of oxygenation of lakes and streams. Falls and rapids oxygenate undersaturated water and deoxygenate supersaturated water; green plants, attached and planktonic, oxygenate water in sunlight and deoxygenate it at night. The detritus on lake bottom is a strong deoxygenating agent.

Just what the individual effort of each of these factors, including wave action, has on the oxygen content of water in the subject of a special study being carried on by the Ontario Fisheries Research Laboratory at Toronto and at the field station on Lake Nipissing.

REPORT OF THE DIVISION OF PROTECTION AND LEGISLATION

I. T. Quinn

I was absent from the convention in Canada last year and I have not been in a position to prepare a formal report. There has since been set up in the Bureau of Fisheries at Washington a new division with Mr. Talbott Denmead in charge, and I will ask Mr. Denmead if he will be good enough to make a summary report on Protection and Legislation.

MR. TALBOTT DENMEAD: Representing the Bureau of Fisheries I had an opportunity to travel from Maine to the south, Alabama and Georgia, during the past four or five months, and I have made a special investigation of a number of large power dams. The power dam question is a very serious one; at the same time it offers a field for some fine fishing. I was particularly interested in Muscle Shoals, which is a wonderful body of water containing many fish. A serious condition prevails there at the present time, arising from the fact that the War Department, in conjunction with the health authorities of the state of Alabama and for the purpose of eradicating the malarial mosquito, raises and lowers the water level of Wilson lake every ten days during the spawning season. A number of persons told me that they had slashed around in their rubber boots at the low ebb of the water among the dying fish and spawn which are exposed to the sun for days at a time. I think that is one matter in respect to which this committee of Mr. Quinn's and the American Fisheries Society can help. I believe plans have already been made to deal with the situation, under which no changes will be made in the water level during the spawning months in the coming spring.

I also had the pleasure of investigating one of the finest bass territories I think I ever saw. Last week I went up to what they call lake St. Francis in this great state of Arkansas and viewed a wonderful small mouth bass territory which is now absolutely ruined by the construction of ditches for the purpose of flood control. The effect has been to reduce that magnificient bass area to a muddy stream. I believe arrangements can be made through such agencies as the United States Bureau of Fisheries, the American Fisheries Society and organizations of the kind to restore that area to its former pristine glory.

I have visited other power dams and have come upon a great many legislative matters that I think should be attended to and in respect to which this association can take the lead. I shall in the talk I am to give on the Federal Black Bass Law refer to certain conditions existing in many of the states, and I shall not go into them at this time. I certainly would like to see this Society, which is more scientific than otherwise, take a more active and greater interest in game and fish legislation and protection.

APPOINTMENT OF COMMITTEES

Auditing: T. H. Langlois, Chairman, George A. Berg, A. B. Cook.

Nominations: C. F. Culler, Chairman, A. H. Wiebe, John L. Farley, Eben W. Cobb, I. T. Quinn.

Resolutions: H. S. Davis, Chairman, J. A. Rodd, Emmeline Moore, Lee Miles, Walter Shirts.

Time and Place: John W. Titcomb, Chairman, Lee Miles, Burnie Maurek Carl L. Hubbs, Ben Mobley, Albert Powell, C. C. Woodward.

REPORT OF COMMITTEES

REPORT OF THE AUDITING COMMITTEE

Mr. Tucker for Mr. Langlois: The Auditing Committee makes the following report:

The Auditing Committee has checked the books and vouchers of the treasurer and finds the report of the treasurer as submitted to be correct.

We recommend that $100 be allowed for additional clerical services for the past year, and that for the year 1931-1932 the total apropriation for such clerical work and additional services be $250.

The adoption of the report was moved and carried unanimously.

COMMITTEE ON TIME AND PLACE

MR. TITCOMB: This report will be submitted by the secretary of the joint committee, Mr. Brown of Vermont.

MR. BROWN: Your committee conferred with the committee appointed by the International Association of Game, Fish and Conservation Commissioners, and it was unanimously decided to hold the next joint meeting at Baltimore, the last full week in September.

Adoption of the report was moved and carried unanimously.

COMMITTEE ON RESOLUTIONS

Carlos Avery

The officers and members of the American Fisheries Society here assembled desire to record their deep appreciation of the invaluable services rendered this Society in particular, and Wild Life Conservation in general, by their late lamented Secretary-Treasurer, Mr. Carlos Avery, and to express their sincere sympathy to his family.

Regulation of Waters

WHEREAS, the impounding of waters and the fluctuation of levels and flow of impounded waters results in the loss of fish and destruction of their spawning and breeding habitat, and

WHEREAS, pollution of our streams tends to create conditions injurious to fish life, as well as to live stock and to human health, and

WHEREAS, economical and practical pollution control measures undertaken by municipalities and industries can be effective only on streams where reasonably continous flows are present, and

WHEREAS, sections of many streams now suffer from so-called "regulation" in connection with the storage of waters for the development of power and other purposes, and

WHEREAS, the construction of drains and irrigation projects has seriously effected the levels of inland lakes; changed the character and affected the volume of stream flow; restricted or destroyed the range of our fish and other aquatic life.

Therefore, Be It Resolved. That the American Fisheries Society strongly endorses the enactment of legislation which will vest state aid or federal authorities with power needed to properly regulate the use and flow of waters and control pollution; the impounding of waters and their release; the construction of drains; and the withdrawal of water from inland lakes and streams.

Uniform International Regulations

The American Fisheries Society recognizes the progress made between the United States and Canada toward the adoption of uniform regulations particularly as regards the fisheries of the Great Lakes and other inland boundary waters; it commends the efforts put forth by the International Fisheries Council of the Great Lakes in sessions held at intervals since 1928 and it urges consummation of these negotiations at the forthcoming conference called by the Conservation Department of New York State to meet at Buffalo, New York, October 12, 1931.

Acknowledgment of Courtesies

Resolved, that we express our sincere appreciation for the attractive program and cordial hospitality which have characterized the Sixty-First Annual Meeting of the American Fisheries Society, and that we extend our sincere thanks to His Excellency, Governor Harvey Parnell of Arkansas, to His Honor, Mayor McLaughlin of Hot Springs, to the officials of the Arkansas Game and Fish Commission, and to the Garland County Game and Fish Protective Association.

We also express our appreciation to the Chamber of Commerce of Hot Springs for courtesies received and to the Arkansas Press for the publicity given to the meeting.

We further express our appreciation to the Management of the Arlington Hotel for the many courtesies extended which have contributed greatly to the comfort and pleasure of our members and to the success of our Meeting.

The resolutions as submitted by the Committee were unanimously adopted.

COMMITTEE ON NOMINATIONS

MR. QUINN: The chairman of the Committee on Nominations had to leave this afternoon, and turned this report over to Mr. Cobb, who insists that I read it. Your Committee on Nominations submits the following list for consideration as officers of the society for the ensuing term:

President—J. A. Rodd
Vice-President—H. S. Davis
Secretary-Treasurer—Seth Gordon
Librarian—John W. Titcomb

Vice-Presidents of Divisions

Fish Culture—G. C. Leach
Aquatic Biology and Physics—A. H. Wiebe
Commercial Fishing—N. B. Scofield
Protection and Legislation—Talbott Denmead
Angling—I. T. Quinn

Executive Committee

Fred A. Westerman, Chairman
Clarence Birdseye
Lee Miles
Thaddeus Surber
C. F. Culler
T. H. Langlois
Burnie Maurek

Foreign Relations

Henry O'Malley, Chairman
A. G. Huntsman
Frederic C. Walcott
Judson L. Wicks
W. F. Thompson

Relations with Foreign and State Governments

Lewis Radcliffe, Chairman
John Van Oosten
Charles R. Pollock
John P. Babcock
C. C. Woodward
Emmeline Moore

Committee on Publication

John W. Titcomb, Chairman
David L. Belding
George C. Embody
H. S. Davis

On motion of Dr. Emmeline Moore, seconded by Mr. Tucker, the report was carried unanimously, and the Secretary was instructed to cast one ballot for the list as read.

Retiring PRESIDENT LECOMPTE: I wish to express my appreciation of the action of the members of this Society in electing me to the office of president in Toronto in 1930. I hope I have served you well; I have done the best I could. I assure you my heart is always with you in your great work. It is with pleasure that I relinquish the office to my successor, Mr. Rodd.

PRESIDENT ELECT RODD: Thank you very much, Mr. LeCompte, I feel sure that I express the views of everyone hear when I congratulate you most heartily on the success of the Sixty-first Annual Meeting of the American Fisheries Society.

Ladies and Gentlemen, I deeply appreciate the honor which you have conferred upon me in electing me to this high office. The honor is the greater because of the long line of distinguished persons who have preceded me, and also because I believe I am the first Canadian who has ever been president of this Society. I feel that in honoring me with this office you are doing so primarily as an act of courtesy to the country to which I belong and the department which I have the honor to serve, and I deem it a privilege to be the medium through which that courtesy is conveyed.

I am diffident of my ability adequately to fill a position the duties of which have been so ably discharged by my distinguished predecessors, but I assure you that with the advice and assistance of every member of the Society I will do my utmost to carry on in the best interests of the organization.

I thank you again for this honor, and I hope to see you all, with many more, next year at Baltimore.

Whereupon the Sixty-first Annual Meeting of the American Fisheries Society was adjourned, to meet at Baltimore, Maryland, in September. 1932.

MINUTES OF MEETING OF THE EXECUTIVE COMMITTEE AND OFFICERS OF THE AMERICAN FISHERIES SOCIETY

A meeting of the Executive Committee and officers of the American Fisheries Society was held at the Arlington Hotel, Hot Springs, Arkansas, on September 20, 1931, those present being as follows:

E. Lee LeCompte, President of the Society; John W. Titcomb, Librarian; H. S. Davis, Chairman of the Executive Committee; James A. Rodd, Vice-President; Guy Amsler, Thaddeus Surber and Seth Gordon.

After discussing the desirability of a Program Committee to agree upon the sequence in which papers should be presented, President LeCompte appointed a Program Committee consisting of Messrs. Titcomb, Rodd and Davis.

The Secretary-Treasurer presented to the officials of the Society the desirability of defining the membership year and fixing it either to agree with the calendar year or to terminate at a definate time during the middle of the year. After discussion it was decided that the membership year shall terminate June 30 of each year.

The desirability of investing the balance in the savings account of the permanent fund in good securities was discussed and it was moved by Mr. Amsler, seconded by Mr. Titcomb, that the Treasurer confer with the Irving Trust Company or Senator Walcott relative to the investment of this balance.

The Secretary-Treasurer was authorized to transfer the checking account of the Society to a Washington bank of his selection.

The terms under which extra copies or bulk orders of the Transactions should be disposed of was discussed at some length and it was decided to leave the matter in the hands of the Librarian, Mr. Titcomb.

The wisdom of exchanging Transactions with foreign correspondents and sending Transactions to honorary members was considered and upon motion of Mr. Amsler, seconded by Mr. Surber, it was agreed that the list of honorary and corresponding members shall be closely scrutinized and that the President, the Librarian and the Secretary acting as a committee shall eliminate those to whom copies of the Transactions should not be sent.

The question of using the income from the permanent fund to offer prizes for outstanding papers and accomplishments or to publish and distribute abstracts was discussed at length. Upon motion of Mr. Amsler, seconded by Mr. Surber, it was agreed that the chair shall appoint a committee of three to study this matter and report to the officers and Executive Committee at a meeting to be held prior to the 1932 annual meeting. Thereupon the President appointed Messrs. Titcomb, Davis and Surber as members of this committee.

SETH GORDON, Secretary.

In Memoriam

George L. Alexander

C. C. Bolton

E. T. D. Chambers

J. L. Collins

W. H. Griffith

William Haas

G. H. Lambson

F. S. Landstreet

Henry C. Rowe

George P. Slade

Lewis H. Smith

W. W. Thayer

PART II

PAPERS AND DISCUSSIONS

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MAKING THE MOST OF A LIMITED WATER SUPPLY IN TROUT REARING

EBEN W. COBB

This is not intended as a scientific treatise on fish culture. It is an attempt to throw a little light on our method of solving the problem of supplying, with the means at hand, the greatest number of good trout.

We have worked on the principle of making the conditions suit the fishes rather than compelling them to adapt themselves to their surroundings. It is taken for granted that the water supply is of good quality and that we are dealing with artificial surroundings only.

It is generally accepted that rearing ponds should be so constructed that the current is continuous throughout their length. This serves a dual purpose—the fishes have exercise in facing the current and the current aids in keeping the pond clean. This system, however, while it is in common use and works very well, has the disadvantage of providing very little room for the fishes. They are likely to spend their time for the greater part in the upper portion of the pond, especially at feeding time, and for this reason the full capacity of the pond is not utilized.

These ponds are usually cleaned by lowering the water and brushing down the filth. During this process the quality of the water is not good and the water supply for the ponds lower down is affected while the upper pond is filling up. A number of these ponds are in use on our stations and, when limited to their capacity, they give very good results.

The circular pond which was reported last year has proved an advance. We have worked on it and have constructed others of various sizes. We have also experimented with a variation in shape. It may be of interest to set before you some of the results obtained.

The pond described last year carried through the winter and furnished for distribution during the spring 4,300 brown trout, weighing 2,700 pounds. This was a considerable increase over the number reported last year and no bad results ensued.

At another place on our grounds narrow dirt ponds with a total length of about 160 feet were discarded and two circular ponds 31 feet in diameter, with a depth of 20 inches, were constructed to replace them. They were placed tandem and the water supply of the original ponds was used. The capacity of the line of old ponds was 9,000 fingerlings reared

to five inches. One of the new ponds is carrying about 10,000 five inch brook trout and the other approximately 12,000 brown trout, average length 4 inches. The number carried and the growth rate both show an increase and, at the same time, there has been a decrease in the labor involved.

At still another location we discarded a series of narrow dirt ponds with a total length of 45 feet and constructed in place of them three circular ponds—two 20 feet in diameter and 14 inches depth, and one 25 feet in diameter and 18 inches in depth. With the same water supply the capacity has been increased about 100 per cent.

At one of our new stations, where the soil was not of a consistency to hold the banks of dirt ponds in good shape, and where we wished to use the circulatory system, we used plank sides. Oblong ponds were constructed and the corners cut so that a very good revolving current was obtained. For some reason, however, when the pond was siphoned off, the current would break and carry the refuse to one side of the pond or the other. These oblong ponds are fairly satisfactory but not so much so as the circular ones.

The greater part of our brook trout are from six to nine inches in length and twelve to fifteen months old when planted. We have not been able to produce brown trout over six inches in length at so early an age. At present we have a good number of brown trout fingerlings in circular ponds and, while they vary in size, there is a prospect that about thirty per cent will be the right size to plant during the next fishing season. It is too soon to make a definite statement, but it may be said that these trout are much better than in former years.

For many years we have reared trout in standard troughs—14 in. x 8 in. x 12 ft., both indoors and out. Our records show that trout reared in these troughs are smaller than those reared in ponds and that they require more food and labor expended than do the same number in ponds. As it is very often convenient to rear them in troughs efforts have been made to improve conditions.

In a portion of one of our trout nurseries larger troughs were used to take the place of the double troughs and the results were very gratifying.

At one of our hatcheries we were using troughs, about 6 in. in depth, built in pairs, set tandem with a lower pair. These were not standard troughs but an odd size constructed several years ago. No difference in the rate of growth of the trout in the upper and the lower sets was observed. We replaced the upper pairs with trough 11 ft. 3 in. long by 2 ft. 10 in.

wide and 16 in. deep. They carried 12 in. of water. Each of these deep troughs replaced one pair of the smaller troughs and was supplied with the same amount of water as the smaller pair. The trout scattered through the entire length of the trough more uniformly than in the smaller troughs and did not rush madly about when anyone passed between the sets of troughs. They also took food more readily, and comparatively little waste was caused by washing of food through the outlet screen. More trout are being reared in one large trough than had been held in the pair which it has replaced. In some instances the growth is fifty per cent above that in the shallow troughs. During this season we have taken for shipment from one of these troughs as much as fifty pounds of fingerlings, consisting of 1,750 trout of 4½ in. average length. A sufficient number of the shallow troughs should be kept to furnish room for hatching. At the time when thinning out is desirable the large troughs can be used.

The large trough can be taken care of in less time than two smaller ones. To minimize trouble in the lower troughs while the upper ones are being cleaned, the refuse in the upper is brushed to the lower end before the outlet plug is removed. An even better method is to use a siphon. We find the siphon of great use not only in cleaning troughs but in cleaning the circular ponds and the lower end of small ponds wherever conditions permit. All new construction is planned with this in view. With the siphon the flow of water is not stopped, though it is diminished somewhat during the time of actual cleaning.

Our object is to give the trout space and current, even although it is the same water that is circulated several times to create that current and to provide conditions whereby the trout derive full benefit from the food supplied. Some years ago one of our members spoke of the trout as being a nervous fish. This remark caused a ripple of laughter through the room, but it was not a joke. Fish culturists know that when anything unusual has happened to them, trout become excited so that they will not take food. At our largest hatchery, which is visited by thousands of people, especially on Sundays, the trout in the narrow or shallow ponds take very little food after the Sunday morning feed. As visitors walk between these narrow ponds the trout pass up and down the length of the pond continuously. In the circular ponds the trout are not so much disturbed.

We do not claim to have gone very far but we do feel that, with the changes made in construction, we are making some

headway. Our work for the past year has shown an increase in the weight of trout produced as a whole; the average weight per trout has increased, and, at the same time, we have reduced the amount of food used. This reduction in the food bill is largely the result of intensive food nutrition experiments conducted during the past five years, though changes in pond and trough construction have been important factors. Further trials may determine to what extent these changes can be carried on to secure beneficial results.

The above discussion is not intended to apply to large ponds for wintering purposes, but refers only to rearing ponds for fingerlings.

Discussion

MR. LAIRD (Long Island): I did not hear Mr. Cobb say what flow of water was used in the 30 foot pond. Will he tell me?

MR. COBB: In giving the comparison I stated that the same water was used in that pond as had been used in the series of longer dirt ponds. In the circular ponds you have to have enough to give a circulatory movement. The amount can vary, because you can use velocity if you have a head to replace the water used in creating the current. In a pond of that size I should not undertake to circulate less than 75 gallons per minute.

THE INFLUENCE OF HEREDITY ON THE SPAWNING SEASON OF TROUT.

H. S. Davis

U. S. Bureau of Fisheries.

We have been accustomed to believe that the time at which trout spawn is determined primarily by the temperature of the water. In northern latitudes where the temperature drops rapidly early in the fall trout spawn earlier than in localities farther south. Consequently, it has been assumed that it is simply a matter of temperature and that when the water becomes cold enough in any particular locality the trout will straightway proceed to spawn.

But when one stops to reflect on the matter, it becomes evident that this is not all of the story by any means. If it is simply a matter of temperature, why should not all of the trout in any particular stream spawn as soon as the proper temperature is reached? Yet we know that as a matter of fact this is not the case. Wild trout in any locality can be seen spawning for a month or more and every fish culturist is familiar with the fact that the brood stock in our hatcheries usually spawn over a period of several weeks.

The situation in hatcheries, is still more anomalous if the spawning season were determined primarily by temperature conditions. The great majority of our trout hatcheries are supplied with spring water which shows very little fluctuation in temperature throughout the year. The brood fish are kept in pools where the temperature varies but a few degrees from summer to winter and where there is no marked decrease with the approach of the spawning season. Nevertheless, these trout usually spawn at approximately the same time as wild fish which are exposed to much greater variations in temperature. Obviously, there must be other factors affecting the time at which trout spawn which are fully as important, if not more so, than the influence of temperature.

The trout used in the breeding experiments at the Bureau's hatchery at Pittsford, Vermont, exhibit the usual variations in the spawning date, the season for brook trout extending from the last week in October through November, although all the brood fish are kept under practically the same conditions so far as temperature is concerned. It has been found, however, that while mixed lots of fish continue to spawn for several weeks, those with a common ancestry usually have a

much shorter spawning season and in some instances are all ready to spawn at practically the same time.

This is strikingly shown in one lot of fish, containing over 100 females, which were all the offspring of a single pair. This lot has been stripped two years in succession, and each year these fish were among the first to spawn. In 1929 nearly all of this lot were ready to spawn on October 29, and the eggs were taken from the remainder on November 6. In the following year (1930) most of these fish were ripe on October 25, and the remainder were stripped November 4. Here we have a lot of fish, all full sisters, which were ready to spawn on approximately the same date in two successive years and, what is perhaps even more striking, all were ripe at practically the same time. Instead of the spawning season being spread over a period of several weeks, all of the fish were through spawning in about a week. It is interesting to note that in 1930 these fish were in a pool containing two other lots, both of which had a much longer spawning season, namely from October 25 to November 19.

While this is the most striking instance we have as yet obtained of the influence of heredity on the spawning season, we have other data which point strongly in the same direction: The mother of the fish just referred to was stripped three years in succession, but unfortunately the date on which the first lot of eggs were taken has been lost. However, our records show that this fish was stripped on November 1, 1927 and again on November 6, 1928. It will be noted that these spawning dates agree very closely with those of her daughters.

Our records also show that a small lot of fish from another pair hatched from eggs taken October 26, 1927 were stripped October 30, 1930. Unfortunately, this lot contained only five females, but all of these were ripe on the same date. An older lot of fish from the same female, but by a different male, were stripped November 8 and 15, 1929 and November 4 and 14, 1930.

Evidence of a somewhat different nature is afforded by the fact that at the Pittsford station we have two strains of rainbow trout, one of which spawns in December and January, the other in April and May.

Meager and incomplete as these data are, I think they point very strongly to the conclusion that heredity rather than temperature is the primary factor in determining the date at which trout will spawn. Of course, this does not mean that temperature and other factors are of no effect, but it must be

evident that they are of secondary importance. This being the case, it opens up some interesting possibilities of far-reaching importance to the trout culturist.

If the spawning season is determined primarily by heredity, it means that the trout culturist can, to a certain extent at least, control the spawning of his fish, and instead of waiting for them to spawn over a period of a month to six weeks, or even longer, it should be possible to shorten the season to less than one-half that time. This can be accomplished, of course, by rearing brood stock only from fish which spawn at a certain time. If this is rigidly adhered to, in a few generations we should have a strain of fish which would all spawn on approximately the same date. The advantages of this are obvious. The operation of taking and caring for the eggs would be greatly simplified. Instead of having a number of lots which must each receive different treatment, all of the eggs could be handled alike. The fingerlings would be uniform in size and for that reason could be cared for more efficiently and economically than when split up into several lots of different sizes.

Furthermore, there would be less injury to the brood fish, which is an item of no little importance, and eggs of better quality would be obtained. In our own experience we have found that eggs taken near the close of the usual long spawning season are ordinarily much inferior to those taken earlier. This appears to be due to the fish having been handled several times, which certainly does them no good, and also to their having been kept in close confinement for several weeks. It is well known that in many other species of fish, such as the grayling and pike-perch, only those fish which have been closely confined for a very short time produce good eggs. Why should we not expect trout to react in a similiar manner? Certainly we should not expect the treatment to which they are necessarily subjected during the spawning season to have a beneficial effect on either the fish or the eggs.

There is still another possibility which is worthy of consideration in this connection. Not only will it be possible to develop strains of fish which will all spawn at practically the same time, but it will also be possible to determine, within limits of course, the date at which this operation will take place. In other words, we can develop either early or late spawning strains of trout as conditions may require. In northern New England, for example, an early spawning strain would be especially desirable. In these states handling fish during the bleak days of November and December is anything but

a pleasant occupation. Furthermore, owing to the low temperature of the water and the consequent slow growth of the fingerlings in this section, it is difficult to rear yearling trout which will reach legal size until late in the following summer. For these reasons a strain of trout which can be depended upon to spawn early in the season will have many advantages over those commonly found in our hatcheries.

Finally, may I remind you that this is only one of many improvements in our trout which we may confidently expect as a result of selective breeding. More rapid growth, early maturity, increased egg production, greater resistance to disease and a shorter spawning season are all qualities which we may look for in the trout of the future. And these, I believe, can all be attained without sacrificing in any degree other qualities which have given trout a pre-eminent position among our game fishes.

Discussion

MR. TITCOMB (Conn.): In the collection of wild trout eggs we find that the early spawners give comparatively small eggs of irregular size; while those that spawn during the height of the season give a uniformly larger egg. At the close of the spawning season, which extends over a period of six weeks, the eggs again are small and not so satisfactory. Is there any way of accounting for this condition?

DR. DAVIS: I do not think there is any way of accounting for the small eggs early in the season. In general the younger trout, those spawning for the first time, usually spawn a little later than the older fish and naturally their eggs are smaller.

MR. TITCOMB: I have reference more particularly to wild trout.

DR. DAVIS: Our experience with hatchery fish does not indicate that the eggs are smaller earlier in the season. Some of our very best eggs were taken on the 25th of October.

MR. LAIRD (New York): What is the comparison in quality between two and three year old brook trout eggs? Is there any real advantage in taking eggs from three year old fish as compared with the two year old fish?

DR. DAVIS: As far as our experience is concerned I do not think there is any appreciable difference. We have found that the yearlings will not in general give as good eggs as the two year old fish, but I doubt if there is any appreciable difference between the two and the three year old fish.

MR. LAIRD: From a financial standpoint it is more economical to take eggs from two year old fish?

DR. DAVIS: We have abandoned taking eggs from yearling fish except in particular instances. The small number of eggs and their poor

quality do not compensate for the injury to the fish and for the time spent in taking the eggs.

MR. BURR (Texas): Would the same principle with regard to temperature prevail in respect to bass?

DR. DAVIS: I do not think it would apply to bass.

MR. LANGLOIS (Ohio): I am inclined to think the same principle might apply to bass. In our hatcheries in Ohio we lose a great many of the eggs as a result of the early spawning of the bass. The best fry are from the bass that spawn after the dangers of a cold spell are past. Inasmuch as we are attempting to develop a brood stock from our domestic fish, we are selecting the late spawning fish.

DR. DAVIS: I may say that my answer was predicated largely on the fact that at certain hatcheries, in order to retard the spawning season of the bass until later in the year, the bass are in ponds which are supplied with cold spring water, so that they spawn later than if kept in warmer water.

MR. RODD (Ottawa): In our hatchery work the early spawning of brood trout is of vital importance. Our experience has been much the same as that of Dr. Davis. We have at one hatchery a female trout which spawns early in October every year, while at the same hatchery mixed lots from various sources, will spawn in January. In that particular location handling spawning trout in late January is not an easy matter since the trout must be obtained from under the ice. Naturally we have saved all the fry from the eggs of this early spawning female in the hope that we will obtain an October spawning strain.

DR. HUBBS (Michigan): May I ask Dr. Davis if there is any reason to suppose that either natural or artificial selection has been responsible for the development of fall and winter spawning rainbow trout in the Ozark region, and in Pennsylvania?

DR. DAVIS: Yes, I think it has had a great deal to do with it. Of the two stocks of rainbow trout at the Pittsford station, which spawned at different times, one came from White Sulphur Springs, West Virginia hatchery, where they have developed spawning at a comparatively early period, while the other was from wild rainbows from the Madison river, Montana, which spawn in the spring. Undoubtedly the reason that these rainbow trout which have been introduced in the east spawn earlier than in the west is that the fish culturists by saving the large more rapidly growing fish for brood stock have, perhaps involuntarily, selected an early strain, naturally early spawners because they start growing early.

DR. HUBBS: Has that been true in the Ozark region also?

DR. DAVIS: Mr. Thomas says it is true in the Ozark as well.

TROUT STREAM IMPROVEMENT IN MICHIGAN

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Maintaining trout fishing at its former standard of excellence is proving to be a serious problem. Fish hatchery methods and fish culture are only two of the necessary steps leading to more and better trout fishing in our streams. Some thought must be given to the welfare of the fish after planting, and attention to improving the habitat. We can no longer depend merely on stocking because if conditions in the stream itself are not favorable, we cannot hope to be successful in producing large numbers of fish of suitable size. Conditions in the waters themselves must be bettered if the fish are to have adequate cover and food. It is possible to improve a stream considerably in counteracting the natural deficiencies by artificially improving upon what has been naturally provided or by restoring what man has destroyed.

Deforestation and lumbering practices have nearly ruined many of our streams, the former has removed shade and cover and has caused quick run-offs which are carrying immense quantities of ruinous sand into the streams every year, covering up the spawning beds and food producing areas. One of the methods of lumbering was directly in opposition to the production of trout. Dams flooded the spawning beds, and log drives scoured them out. Flooding for the drives widened the streams and washed into them non-productive sand which covered up the gravel. The rivers were cleared of all jams and cover before the drives and they were swept clear of any vestige of cover by the rush of logs. All these things—the destroying of spawning beds, the covering of great areas with sand, the excessive widening of the stream, and the removal of all cover, are now making themselves harmfully apparent. Perhaps the best way to regulate conditions already disturbed is to restore as nearly as possible original and normal conditions.

This problem is being attempted by the introduction of various types of barriers, hides, and covers. These devices are modeled after those made naturally. It is thought that they will accomplish several things toward restoring the streams to their former condition such as: digging pools, furnishing shade and cover, aiding in the production of more fish, stimulating food conditions, and improving fishing conditions as a sport.

Trout will not remain in a section that has no pools or cover. Pools are made by speeding up the current so that it will dig. This may be done, and has been done successfully, with a wingtype barrier made of log or stone slanted downstream from one bank at a 45 degree angle. This crowds the water to one side and so speeds it up with the result that the current digs a pool. A raft made of logs and wired to the bank can be placed over this pool for cover. By producing more pools we secure more fish in a section because one pool can support only a certain number of fish due to food competition. Many natural pools are so exposed that trout will not lie in them. By putting cover over them they can be made into suitable places for trout. Some of the natural pools have been filled with sand. Speeding up the current will remove this, also. A wing built from each side forcing the stream through a narrow channel in the center accelerates the current and causes it to dig in the sand a gravel bottom pool 100—300 feet long. The sand is piled up in a bar on each side behind the wings, thus the stream proper is narrowed and pools favorable for trout are produced. By means of a wing barrier the current can be thrown under a log so that it will dig a good pool under it. In gravel and stone sections, the wings increase the speed of the current and make a good riffle for a long distance down stream. The fish will stay in the pools and feed in the riffle so that a poor section can be transformed into good fishing.

The headwaters and small feeders coming in at the stream sides can also be much improved. The spawning beds in the headwaters can be changed by the introduction of wings to make the current faster and to keep the gravel beds clean of silt which, collecting on the trout eggs, would smother them. On hard bottoms in which the fish are unable to dig their nests, the wings, by means of the current produced, loosens the bottom material and sorts it so that it may be fit for spawning beds. The work already done on the Little Manistee River has shown that new spawning beds can be made by removing the sand covering from the gravel. As many as eight rainbow beds have been noted around one of these wings where before, the sand made it impossible to spawn. Increasing the spawning areas in this way is a great help because there is then more space for individual nests, and these nests are not so apt to be worked over by other spawners and the eggs destroyed.

The headwaters and sidefeeders can in many cases be made more favorable for the fry and fingerlings. Where the water

is too shallow it can be brought to a suitable depth by placing a low dam of logs or stones across the stream. This will produce an area of still water above it and give a place for the young above the dam. The dark material which collects in the still water is the habitat of chironomids, midges and other small forms which constitute the natural food of young trout. Plants will grow in this quiet water and furnish protection from predators. By this means, food and cover can be given to the young, and they are prevented from dropping downstream where they would be devoured by the older fish. So by producing natural conditions here near the spawning areas, a larger production of young may be secured.

All barriers tend to increase the amount of food by creating a variety of conditions. While carrying on the active work of building, the barriers, I was able to make one hundred insect counts in varying types of bottom, depth, and current. Plant beds, especially chara, are very productive. Rubble produces more than gravel, and coarse gravel more than fine. The dark material along the stream sides is very rich in smaller forms of insects. The kind, however, of the insect is much larger in the plant beds. Sand is very barren of life,—in fact, I found absolutely nothing in it, in many cases.

As for the sand, itself, a thin layer of it is entirely as destructive as a thick bar. By cleaning the sand off the gravel and concentrating it in a heavy bar behind the barrier, a large area of gravel will be exposed. Dark, mucky material collects on the bars in the still water behind the barriers, as I have already noted, producing food habitats. Plants soon establish themselves in the muck on the bars, making the sandbar useful in place of ruinous. This quiet water behind the barrier is, literally, a rich, warm water nursery for young trout. When the bottom is already gravel the speed of the current sorts out the finer material so that more food will be produced in the coarser material that remains. I have also found that, up to a certain point, (not exactly determined), a swifter current produces a greater quantity of food.

The larger forms, such as stone flies, hellgramites, and certain caddis and may flies prefer a swift current. The still, shallow water behind the barriers make a suitable environment for the smaller forms of life, such as protozoa, and algae forms which are the food of trout stream insects. The wings concentrate all the drift food into one food channel and send it over the pool below, with the result that the trout can secure more of the drifting insects which may have fallen into the stream.

From information gleaned from fishermen this year and last, the barriers improve fishing conditions in general and fly-fishing in particular. Different types are constructed so that each pool is slightly different than the next and gives slight versatility in fishing. The food channels thrown along the hides and covers make excellent places for dry-fly fishing since the barriers localize the fish for the fishermen. Fish have been reported caught from under barriers that were not twenty-four hours old, and as many as six fish have been taken from, under another. A sand section on the Little Manistee River, which fisherman invariably omitted, after improvement last year, has been fished with success this year.

There are at present 850 barriers under observation in the following rivers: Little Manistee, East Branch of the Black, Pigeon, Huron, Rifle, and Gamble. Data are taken on each barrier constructed so the original conditions are known and any change can be noted.

The cost of improvement in a stream averaging 30-40 feet in width is $100.00—$200.00 per mile, varying with the stream condition, the availability of material, and solidity of bottom. This year a flood test was carried on in the Pigeon River where 71 barriers built there were exposed with intention to a 22 inch flood slightly higher than a normal spring flood. None of the barriers were lost.

In conclusion, during the two years of field demonstration, this project of trout stream improvement has been successful on the whole. It is planned to continue the work next year in various streams in the State, with a check of those dams built this year, in the hope of further progress and success.

Discussion

Dr. Carl Hubbs: Reference has frequently been made to the fact that a great many of our trout streams have been rendered poor for the trout by the operations of the lumbering days. Streams were cleared of their snags, logs and other obstructions, so that the logs could be floated down stream, with the result that habitats favorable to trout have changed into a shallow, sandy areas where trout are infrequently found. It has occurred to a good many of us that these trout streams could be improved and that we could get back to the so-called pristine conditions by the introduction of cover. The Department of Conservation in Michigan has undertaken on a fairly large scale experiments to determine whether or not this can be done. The experiments are being conducted by the Institute of Fisheries Research at the University of Michigan. Last year a considerable number of such barriers were put into one of

our streams, the Little Manistee. Mr. Tarzwell later checked this work over and found that a very large percentage of the barriers remained in the streams over the winter. Unfortunately we did not have any very large floods in the spring—of course none of these trout streams in northern Michigan flood very much, but the flood water was less than usual—so that we do not know as yet how permanent these constructions in the stream will be. We were able to get a better idea of the permanence of these improvements through a test this year on another, the Pigeon River. Something like eighty of these barriers were put into the Pigeon River, and through the courtesy of one of the fishing clubs we were enabled to create a flood to our own liking by raising the flashboards in a dam. The stream was flooded to an increased height of twenty-two inches at the upper end of the series of barriers and seventeen inches at the lower end. Of course those of you in this section of the country, who think of flood waters in terms of ten, twenty and thirty feet, might not think much of such a flood; however, in a northern trout stream a two foot rise is larger than we would expect in the flood season in the spring when the snow is melting. In this test we did not lose one of these barriers; and it was evident, that this amount of flood water for a short time at least was insufficient to destroy any of the installed barriers.

Of course the method of installation of the barriers is a matter of considerable importance. They must be put in securely. Merely taking a log and tying it to the shore with a piece of wire is not sufficient. The barrier must be very well staked. The barriers that we put into the Little Manistee River accomplished everything we expected, such as deepening holes and furnishing shelter for trout. We also expected that vegetable beds would be established in the loose material which had been dug below the barrier. As anticipated there was an increase in the production of food on the barriers themselves, particularly the brush types. The insect food tends to gather on the barriers right where the trout can get at it. Insects, even the little black fly larva, will come from under the stones and congregate on the barriers sometimes within a day after the barriers are set up. By observation we know that the trout take to these holes; and the anglers catch trout in the immediate vicinity of these constructions.

We had anticipated a considerable improvement in the spawning conditions for the trout. This has gone beyond our anticipation. On the Little Manistee there was a stretch of about five miles, with a clean, sand bottom, where the sand had washed in from the sand banks, covering the bottom and producing a condition not suitable to the reproduction of trout. Mr. Tarzwell found that in that stretch of five miles on the Little Manistee the rainbow trout had utilized the gravel beds at practically every barrier. The barriers were put in such a way that the current which was diverted to one side of the stream, removed the sand

from the original gravel bottom which the trout could utilize for spawning.

It has been our custom to put in several types of barriers. The idea has been to build the barriers out of materials available near the banks of the stream, so as to reduce the expense. We have made a good many dams of boulders which have worked very well. If old deadhead logs from the lumbering days are abundant, we make use of them. We have made very satisfactory barriers out of snags and the old pine stumps. The average cost on a stream say thirty or forty feet wide of a single barrier which would produce a good pool, has been found in our experimental work to be in the neighborhood of two or three dollars.

A type of barrier which has been advocated, the Hewitt dam, is not suitable for Michigan, although it may be excellent for the swift streams of New York state. This barrier is made out of logs placed crosswise in the stream, and on top of these logs are placed lengthwise, which in turn are surmounted with heavy wire and brush, producing a cascade, and a pool below. On the narrow Michigan trout streams with low banks such a barrier will tend to flood a considerable area on the sides of the stream.

We are hoping to be able to publish before long a pamphlet describing the methods of construction which we have found suitable, economical and effective in our waters.

MR. TITCOMB: May we not have a description of your barriers.

DR. HUBBS: Many of our barriers are simple in construction. We place out two or three logs end to end, if the stream is wide enough, setting them at an angle from the bank. The most effective angle is about 60 degrees; which will divert the water satisfactorily to one side of the stream and furnish sufficient slope so that the barrier will not catch too much trash. A barrier straight across the stream is not as satisfactory as one set out at an angle of about 60 degrees downstream.

MR. TITCOMB: How do you anchor the logs?

DR. HUBBS: The log type of barrier is anchored by an oak stake, preferably seven feet long, driven down to the water's edge. The logs are attached to the stake, and to the shore, with heavy No. 9 galvanized wire. Many of our barriers are made out of boulders, particularly in wide, shallow streams without any holes. This type of construction has proved successful not only in trout streams but also in bass streams. A V-shaped type of barrier extends out well towards the middle of the stream, leaving enough room for a boat to go down and for the current to go through. That will produce quite a large hole if the bottom is of the type which will permit excavation. The simple cover type is perhaps the most desirable in streams with a solid rock bottom, with firmly cemented gravel, where it is almost impossible to dig holes.

There are several other types of barriers. The type will depend on the judgment of the man who is installing the barrier and the construction

will depend again upon the material which is available on the stream bank and the nature of the stream at that particular point. These conditions, of course, vary a great deal. In a number of places in Michigan the owners of the stream, have put in barriers independently. Sometimes they have done well, and in other instances no favorable results have followed. One thing that must be avoided is the placing of the barriers too close together. The distance between them will depend on the nature of the stream, the amount of current, the amount of soft material on the bottom, and many other factors. It is very difficult to give a general explanation of the various types of barriers. One would have to know the type of stream, the particular conditions, and the barrier which would be suitable for the situation.

MR. TITCOMB: This is a very important subject. Mr. W. Carter Plattz has written what is perhaps the best book on the improvement of trout streams. The methods he describes would be more suitable for the sluggish type of stream, but it is an interesting work. The idea Mr. Hewitt brings out is to apply in each stretch some remedy which the natural environment and the conditions prevailing in the stream seem to call for. I have just returned from Mr. Hewitt's place in the Catskills, and I am much impressed by what he has accomplished on about two miles of the Neversink River, on stretches which are perhaps from one hundred to two hundred feet wide. It is a torrential stream, very rocky. First he runs some logs up and down the stream, about eight or ten feet apart. These logs are cut nearby. Then he lays across the stream a line of logs at the foot of the horizontal logs, notched and spiked into the others; then he lays on these logs heavy woven wire, about four feet wide.

PRESIDENT LECOMPTE: What mesh?

MR. TITCOMB: I should say about six inch, maybe four or five. He lays the wire over a string of logs across the stream at the lower edge and tacks it on to the logs running up and down stream. In that way he has anchored the whole thing together very securely. Then he lays on brush, hemlock principally, to cover the wire, and on top of that he piles stones. He lays another stretch of logs across the stream above the first layer, and anchors these with logs running up and down the stream also, notched and spiked into the others. The whole thing is filled with stones, which are available both above and below these barriers. The result is that in high water the water runs over the whole barrier, but in low water a large portion of it goes through the barriers.

A pool is created not only below the barrier, from four to eight feet deep, but also under the barrier, and in some places the trout have three or four feet under the barrier where they can hide. In the pools thus created there were many large trout. The area which he has changed in this way was originally what the angler calls a "walking area," a wide stretch of water probably a few inches deep. For a small,

narrow stream of course that might not apply, but all the various ideas that have been referred to can be worked out to accomplish the same thing, having regard to the local conditions. I feel that in a great many places we can at least treble the productivity of trout streams by using these barriers.

DR. EMMELINE MOORE (New York): I should like to ask Dr. Hubbs how many snags he put in the five mile stretch on the Little Manistee.

DR. HUBBS: I have not that information at hand. While we have put in close to a thousand barriers, we have placed them primarily as a matter of experiment. We do know they can not be placed too close together. If a stream has a rather rapid current, the barriers may be placed within perhaps 150 to 200 feet from each other. In such streams as Mr. Titcomb has described, where the water is shallow and the bottom smooth, the barriers may be placed so that the pools will be perhaps, in some streams, 50 feet apart. In some trout streams they may be placed closer together than in others. One of the great dangers of the Hewitt barrier is the spreading of the stream over the banks above the dam. Some of our better Michigan trout streams have gone up to 81° and 82° F. this year, and any damming of these streams, even with the Hewitt barrier, which will spread the water only for a short distance over the bank, may ruin them by bringing the temperature in certain years above or beyond the danger point for trout. Mr. Hewitt, in one of his articles, has estimated the cost of installation of that type of barrier at one dollar per foot of width of stream; our barriers have cost only two or three dollars apiece. That matter, of course, is not so important for Mr. Hewitt, who, I understand, is a man of considerable means, but in state work, where the operations are carried on a wide scale, the element of cost cannot very well be overlooked. I do not wish to condemn that particular type of barrier, but there is no doubt that it is not suited to certain conditions of Michigan.

MR. TITCOMB: Without these barriers you may have water stretching over a width of say 100 feet, with rocks protruding all through, catching the sun and heating the water. If you flood these rocks and create a depth of a foot or so of water I do not think you will get the high temperature which results from evaporation around the exposed rocks all through the channel of the stream.

DR. HUBBS: You are quite right so far as a trout stream of that type is concerned, but we have few of them in Michigan. Most of our streams have sandy bottoms and if we flood them the water goes over the banks to form a considerable area of shallow back water. Your statement is almost certainly true for the type of trout stream you get in New York state and throughout a good deal of New England, but it does not apply to our Michigan streams.

MR. TITCOMB: I am discussing the subject from a general point of

view. You cannot, of course, put in a barrier which will flood the banks; you have to select a spot where the banks are sufficiently high to prevent that. Any good angler who has been fishing a trout stream knows where to find the trout; he knows where the good pools are, and it should not be difficult to select stretches of water which have sufficiently high banks to permit the putting in of an obstruction. The idea would seem to be to create in the stretches which are unsuitable for trout the same conditions that you have in the sections inhabited by trout.

MR. LAIRD (Long Island): On Long Island we have the same condition that Dr. Hubbs speaks of as prevailing in Michigan. We have no boulders or logs. In putting in barriers we use two-by-fours and matched boards, drive the stakes in and run the barrier at an angle of 50 to 60 degrees down the stream. We do not have any material readily available with which to make the barriers.

MR. TITCOMB: When you spend $100 for 100 feet of barrier you have something that will last you about twenty years. A pool is created very much like that created by the old log dams of the early days. Mr. Hewitt can afford it, not only because he is well to do but because he proposes to sell the rod privileges on that two mile stretch to forty people next summer at $250 per rod.

MR. E. L. WICKLIFF (Ohio): Would the same principle apply to bass streams?

DR. HUBBS: Recently we put in a few test barriers in bass streams near Ann Arbor. These streams have a firmly cemented bottom which is difficult to handle as the water is heavily charged with lime. The barriers are of the V-shaped type which forces a tremendous amount of current into a small outlet, and holes about three or four feet deep were dug in a bottom which previously was about twelve inches deep. With a tremendous current we were able to dig into the cemented bottom, and produce fishing in stretches where fishing did not exist before. I doubt whether this type of construction can be used in a large percentage of bass streams because of the amount of flooding that will result. Possibly the Hewitt barrier would be better for such a stream or some type of construction which will be down near the bottom and will allow the flood waters to go over its top. In a trout stream, for instance, where the water is shallow and is subject to flood, I think the type of barrier must be some bottom-hugging type which will allow the excess current to go over the top, leaving the bottom unharmed. The current at the bottom of a stream, even in flood, is very slight; the velocity increasing rapidly as you approach the surface of the stream.

MR. BURR (Texas): We have some mountain ranges in Texas and we have succeeded in populating one of the mountain streams with rainbow trout. By the use of suitable barriers we could perhaps create a great many more places that would be suitable for rainbow trout, a situation

which would apply not only to Texas, but to any other southern state which has mountain ranges.

MR. LAIRD: There is one feature in connection with these barriers which has not yet been mentioned. Not only does the construction of barriers provide a place in which the fish may lay their eggs, but it affords them protection from birds and other enemies. In these holes the fish are protected from birds, whereas in shallow waters they are helpless.

THE NUTRITIONAL REQUIREMENTS OF TROUT AND CHEMICAL COMPOSITION OF THE ENTIRE TROUT BODY*

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INTRODUCTION

Since the past year has witnessed the publication of some extensive reviews dealing with the nutrition of fish—(1), we will consider only that portion of the recent literature that has a direct bearing upon our experiments. In one of our earlier studies (2) we found that trout could be alternately stunted and allowed to grow without any apparent injury. Japanese investigators have recently confirmed our findings using carp in studies upon growth during alternate periods of underfeeding and full feedings (3). They find this increases the efficiency of the fish in its conversion of feed into body tissue. More experimental work must be completed to determine if these findings have an application in the trout hatchery.

In a new series of studies upon plaice Dawes (23) has determined the nutritional requirements of this species during growth. Although his data are presented in a form that makes them difficult to compare with those of other workers they are of interest in showing that this fish species is also a very efficient converter of matter.

The concept that fish can derive a portion of their nutrients

*The feeding experiments were financed by the General Foods Corporation and the Connecticut State Board of Fisheries and Game. One third of the analytical work was financed by the General Foods Corporation and the remainder by a grant from the Heckscher Fund of Cornell University.

from substances in solution, has been revived recently through the work of Krogh (4). This Danish investigator finds that glucose can be utilized when dissolved in the water in which the fish is swimming. This finding reverses modern theories and returns to the thesis of Pütter (5). This work has no practical application at the present time unless it is an unrecognized factor in the absorption of calcium from water.

The vitamin needs of fish are still being investigated by German students. Zuntz and Cronheim (6) find that carp must have about one-fourth of their food in the living form such as crustacea if they are to make good growth. They believe these lower forms furnish essential enzymes that are needed to digest the plant foods such as beans and corn. Haempel (7) finds that vitamin deficiencies may produce diseased conditions in fish. Schäperclaus (8) finds there are four requirements for a satisfactory trout feed, first, certain vitamin essentials, second, inorganic bases to neutralize the acids from meat, third, a narrow ratio of protein to carbohydrates and fourth, some inert material to provide roughage. These are essentially the requirements we have developed in the course of our studies.

In an earlier report (9) we discussed the question of the effect of water temperature upon the rate of growth of trout. Gray and Setna (10) have recently failed to find definite scale rings in trout fed throughout the year by hand. This leads them to question inherent rhythm. They feel that at higher water temperatures the trout consumes more food but a smaller proportion of it may be available for growth. Brunner and Endress (11) find that the protein and fat requirements of fish increase as the water temperature rises. They are concerned chiefly with the utilization of stored nutrients from the body of the fish during the winter season when little food is available.

In our preceding reports we have considered the protein requirements of trout for optimum growth but have not discussed the efficiency of conversion of proteins. The Japanese (12) have recently given considerable attention to the economy of the conversion of proteins by trout. They have developed formulae for determining this efficiency. Too little is known, however, of the biological values of proteins for trout feeding to permit their work to have application.

In order to determine whether or not radiation was responsible for the storage of vitamin D in the livers of fish, Bills (13) radiated catfish. Although he did not alter the vitamin D content of the stored fat, he discovered that fish are quite

sensitive to radiation. In an attempt to control trout diseases more effectively we have carried out a series of studies exposing trout to various amounts of ultra violet light. In the preliminary study (22) we found trout to be quite sensitive to radiation but that they could be submitted to limited amounts without injury. Our experiments have recently been repeated and the findings confirmed by German workers (14) who have published similar data.

In a recent report Davis and Lord (15) have pointed out the importance of physical consistency in trout feed. We agree with this conclusion and believe that much of the success in the practical application of laboratory findings to hatchery conditions depends upon the conversion of feedstuffs that are nutritionally satisfactory into mixtures that can be easily fed and are efficiently consumed by trout. This problem is worthy of extensive study. Upon its solution depends to a certain extent, both the incidence of hatchery disease and efficient utilization of water in the hatchery.

Experimental

We have employed the same technique in our feeding trials as that referred to previously (16). In the present report we have continued the plan of first stating the purpose of a given series of trials. This is followed by a table showing the composition of the diets employed. The growth curves are then presented, plotted upon semilogarithmic paper. These curves represent the mean for a given group or in other words show the growth for the average of the group upon the diet of the same number. All weights are recorded in grams and time in weeks. The date of starting the experiment is shown in the lower left hand corner of each chart. Each group of trout numbered 50-200 individuals depending upon the size of the trout at the beginning of the feeding trial. We have not plotted the mortality curves except in chart 2. In all other cases where no mortality curves are presented it can be safely assumed that where growth ceased and the experiment was terminated there was a heavy mortality.

Meat Supplements For Cottonseed Meal and Dry Skim Milk

In our earlier studies we found cottonseed meal was quite satisfactory for trout when used to supply half of the total calories. Diet Nos. 11-15 were designed to test a series of

fresh meats as supplements for cottonseed meal and dry skim milk mixtures. The compositions of the diets fed are shown in Table 1.

TABLE 1.

Diet No.	Cottonseed Meal	Dry Skim Milk	Raw Meat
11	50	25	Liver 25
12	50	25	Spleen 25
13	50	25	Lungs 25
14	50	25	Heart 25
15	50	25	Kidney 25

The growth curves upon these various mixtures are presented in Chart 1. After the first eight weeks the curves are practically parallel lines. The differences in themselves would not be considered significant but in the light of our earlier experiments spleen may be considered somewhat inferior to lungs, kidneys, and liver. Even the best growth, that of No. 11, does not represent an optimum such as that of curve 10 in Chart 2. The mortality in all these groups was low. These diets are all moderately good but their physical composition is not entirely satisfactory. The latter can be readily improved, however. These diets all contain large amounts of protein. In terms of calories or a dry basis the meat employed in these diets is very low, approximately seven per cent. These results are of practical interest in showing that the various raw meats contain about equal amounts of the unknown essential factor we have termed "H". For assay purposes these meat levels will have to be still further reduced although it is probable that such an experiment is not worth while when the results of this one are carefully considered.

The Protein and Mineral Requirements of Trout

In our earliest experiments we found that trout require more than ten per cent of the calories in the form of protein in order to grow. This seems to be quite a general law for higher vertebrates. Since protein is usually the expensive item in feeding any animal species we have designed the following experiments to define still more closely the requirements of trout:

TABLE 2.

Diet No.	D-1	D-2	D-3	D-4	D-5	D-6	D-7	D-8	D-9	D-10
Cod liver oil	5	5	5	5	5	5	5	5	5	5
Yeast (dry)	5	5	5	5	5	5	5	5	5	5
Raw liver	20	20	40	40	60	60	80	80	200	200
Cooked starch	85	80	80	75	75	70	70	65	40	35
Salt mixture	0	5	0	5	0	5	0	5	0	5

The salt mixture consisted of equal parts of bone meal, sodium chloride and calcium carbonate.

The even numbers in this series all contain the mineral mixture while the odd ones have no such supplement. The protein level gradually rises with each pair of numbers from about six per cent in the case of D-1 and D-2 to approximately forty-two per cent in D-9 and D-10.

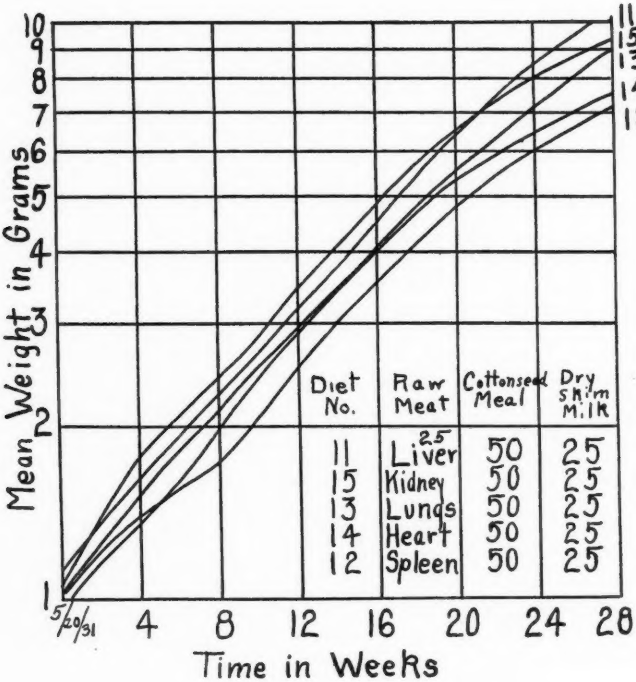


CHART 1

Growth curves of trout fed for twenty-eight weeks a mixture of dry skim milk, cottonseed meal and raw meat (1:2:1). These curves indicate that liver, kidneys and lungs are somewhat better than spleen and heart as supplements for this dry feed.

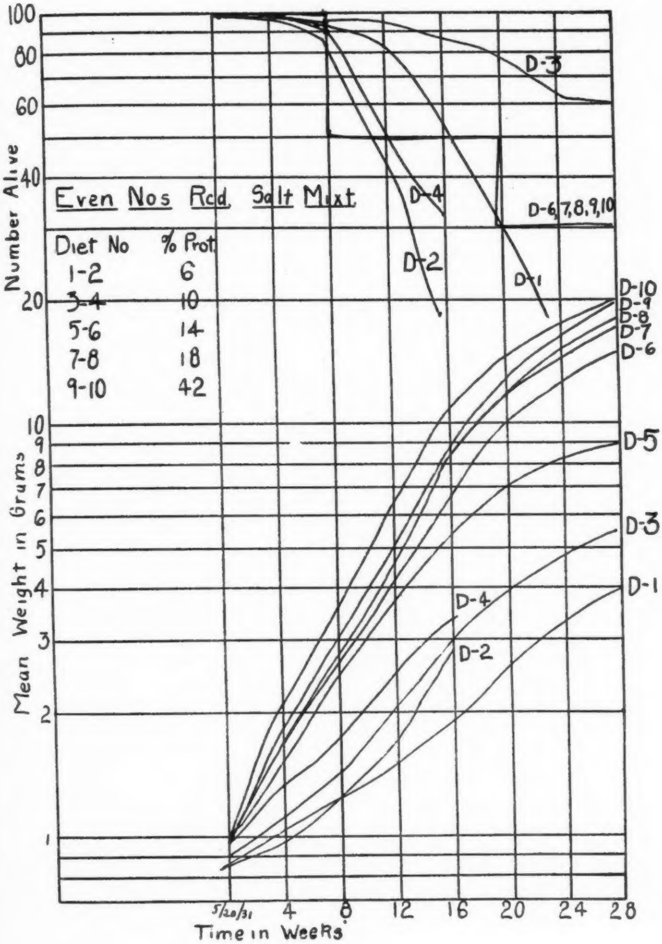


CHART 2

The growth and mortality curves for groups of trout fed varying protein levels (6 to 42%) with and without salt mixture. The even numbers alone, received salt mixture. Those upon protein levels of ten per cent or lower grew more slowly and died after a few months (Nos. 1 to 4). Those receiving salt mixture grew better than those without but also died sooner upon the low protein diets.

In Chart 2, we have assembled both the growth and mortality curves. In every case the even numbers receiving the mineral mixture grew slightly better than the corresponding odd number without it. In the case of the four low protein groups the even numbers grew more rapidly but also died more quickly. This same phenomenon was observed previously (16) under quite different experimental conditions. At that time we noted that if two groups of trout are upon the same deficient diet and one grows more rapidly, it will also die sooner. If this should prove to be a general law one may wonder if the rapid attainment of maturity by the young animal means a shorter life period during the adult stage.

Since groups D-5 and D-6 are slightly below normal in their growth rates we must conclude that the protein requirement is fourteen per cent or slightly higher. We realize that the interpretation of these data purely upon the basis of protein level is impossible due to complications with factor H. By reference to Chart 1, however, where growth and life were possible in the presence of other protein sources but with a very low level of factor H, we believe we are justified in assuming the factor H level to be adequate and the failures to be due primarily to the low protein levels.

The Rearing of Trout Upon Dried Feeds

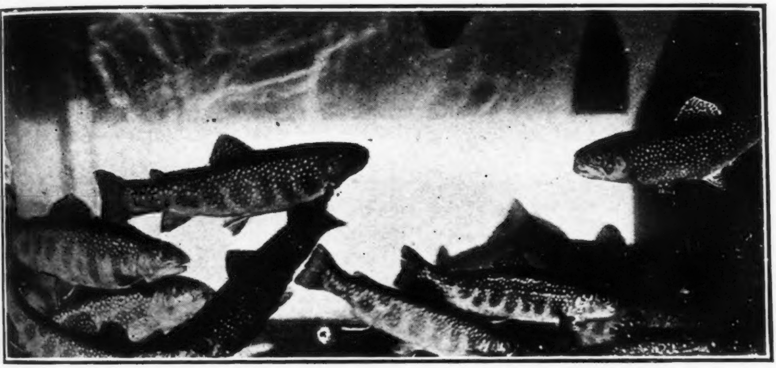
In each of our previous reports we have recorded attempts to rear trout upon diets composed entirely of dry feeds. In no instance have we been able to record previously the continued growth and maintenance of well being in trout for periods in excess of six months, when no fresh, raw meat was allowed.

These failures early caused us to postulate that the essential factor with which we were dealing was thermolabile. It was further assumed by Dr. Tressler that this factor might be destroyed by oxidation either in the course of drying or during storage in the presence of air for appreciable periods of time.

The Preparation of Dry Feeds

(Statement prepared by Stuart P. MacDonald and Donald K. Tressler).

During the past year, the materials furnished by the Birdseye Laboratories, formerly known as Research Laboratory of the General Seafoods Corporation, Gloucester, Massachu-



Photograph of trout reared for more than one year upon diet 92. This Diet consisted of a dry mixture of liver dried upon a base of skim milk. These trout showed an optimum growth rate for fish confined in small troughs. This is probably the first case upon record where trout have been reared for more than one year upon a dry feed only.

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setts, for use in experimental trout studies at the Burlington, Connecticut trout hatchery, have consisted chiefly of fish meal, dried beef liver, and mixtures of dried beef liver and dried skim milk.

The fish meal was prepared from haddock waste from which the heads had been removed. Haddock waste is simply the residue from the filletting operation. After this haddock waste was frozen and comminuted, it was suspended and dried in a current of warm air at a temperature not exceeding 120° F. The dried meal has approximately the following composition:

Protein	60—65%
Ash (chiefly tri-calcium phosphate)	20—25%
Oil (ether extract)	1.5%
Water	8—10%

For purposes of comparison, a meal made by the Dehydrating Process Company of Boston, Massachusetts, was secured. This was supposed to be made from haddock waste. The presence of an appreciable proportion of some sort of oily fish was indicated, however, by the high oil content (5%). This particular fish meal has the following analysis:

Protein	58.74%
Moisture	10.86%
Ash	24.71%
Oil (ether extract)	4.75%

Beef liver, alone, is a sticky material and difficult to dry by ordinary means. It was dried on pans, (1) in a gas oven at 110° C. and (2) in a current of warm air. Neither method was very satisfactory since the consistency was such that the trout would not eat the dried liver readily. The most satisfactory results were obtained when the liver was dried on a heated metal surface so arranged that the drying was accomplished in less than one minute.

An exceptionally fine dried liver is secured in combination with dried skim milk in a rotary vacuum drier. Fresh beef liver is ground fairly fine and mixed with the desired amount of dried skim milk. This mixture is then frozen, comminuted, and placed in the rotary vacuum drier in the form of finely divided frozen particles. The drum, of course, has suitable means of agitation. The temperature of the drier is maintained at about 20° F.; the apparatus is held under a vacuum of about .5 mm. which is lower that the vapor pressure of water over ice at 20° F. When the moisture content has been reduced to about 40 per cent, the temperature can be increased

to 100° F. without causing the material to ball badly or stick to the sides of the drum.

In Table 3 is a list of dry diets with their composition and method of preparation.

TABLE 3

Diet No.	Composition	Method of Preparation
91	50-50 dried skim milk—dried beef liver canned in CO_2.	Mixture of dried skim milk and raw beef liver was dried in rotary vacuum drier at 20° F., later raised to 100° F.
92	Same as 91 plus 10 per cent ethyl alcohol.	Same as 91, alcohol being added just before canning.
1	Beef liver dried at low temperature, canned in CO_2.	Dried on pans in a current of warm air at 120° F.
2	Same as No. 1 except canned in air.	Same as No. 1 except canned in air.
B-2	75-25 dried skim milk—dried beef liver, canned in CO_2.	Same as No. 91 except 75-25 mixture in place of 50-50.
B-3	50-50 dried skim milk—dried beef liver, canned in CO_2.	Same as No. 91.
B-5	75-25 dried skim milk—dried beef liver, canned in air.	Same as B-2 except canned in air.
B-6	50-50 dried skim milk—dried beef liver, canned in air.	Same as B-3 except canned in air.
B-8	75 parts dried skim milk—100 parts raw beef liver.	
B-9	50 parts dried skim milk—200 parts raw beef liver.	
C-1	Raw beef liver.	
C-2	Beef liver, dried at 110° C. canned in air.	Dried in gas oven at 110° C.
C-3	Same as C-2 except canned in CO_2.	Same as C-2 except canned in CO_2.
C-4	Beef liver, dried at low temperature, canned in air.	Same as No. 1.
C-5	Same as C-4 canned in CO_2.	Same as No. 2.
4-A	Equal parts cottonseed meal, dried skim milk and Dehydration Process Company fish meal.	Fish meal made by Dehydration Process Company, Boston, Mass.
4-B	Same as 4-A plus 25 per cent raw beef liver.	

Diet No.	Composition	Method of Preparation
4-C	Same 4-A plus 6 per cent dried liver.	Liver dried as in No. 1, and whole mixture canned in CO_2.
5-A	Same as 4-A except for low temperature fish meal in place of Dehydration Process Company fish meal.	Fish meal was made from haddock waste, which was frozen, comminuted, and dried in moving air current at about 120° F.
5-B	Same as 5-A plus 25 per cent raw beef liver.	
5-C	Same as 5-A plus 6 per cent dried beef liver.	Liver dried as in No. 1, and whole mixture canned in CO_2.

(Conclusion of statement of MacDonald and Tressler)

In Chart 3 we have drawn the growth curves obtained by feeding diets C-1 to C-5. These show that liver dried at a low temperature is superior to that dried at 110° C. Liver dried and then preserved under carbon dioxide is more potent in both cases than that exposed to air during storage. None of the dried liver products were equal to raw liver. From the results shown in later charts this seems to be a question of physical consistency.

In Chart 4 we present the growth curves for diets 4 ABC and 5 ABC. This series of diets was designed for two purposes:

(1) to compare two different fish meals as possible ingredients of a trout feed when combined with cottonseed meal and dry skim milk. It was assumed that if one should prove to be a more potent source of the growth factor the growth curve would reflect the superiority. For that reason all containing one fish meal are numbered 4 and the other 5.

(2) to determine if liver dried and preserved at a low temperature in carbon dioxide can replace raw liver as a supplement to this mixture of cottonseed meal, dry skim milk and fish meal.

The curves indicate that the dry liver under these conditions retains part of its potency. The extent of the destruction of the factor H is probably masked in this case by the problems of physical consistency. This latter explanation is questionable, however, due to the excellent growth during the first twelve weeks. In regard to the relative value of the two fish meals in question, one would hesitate to draw conclusions upon the basis of any two sets of curves, but since those numbered 4 are consistently better in all three cases, that fish meal would seem to be superior.*

*These two meals are not comparable since the fish meal used in 5-A, 5-B, and 5-C was made from waste from haddock, which is a non-fatty fish, whereas the meal used in 4-A, 4-B, and 4-C was manufactured from waste from a mixture of fatty and non-fatty fish.

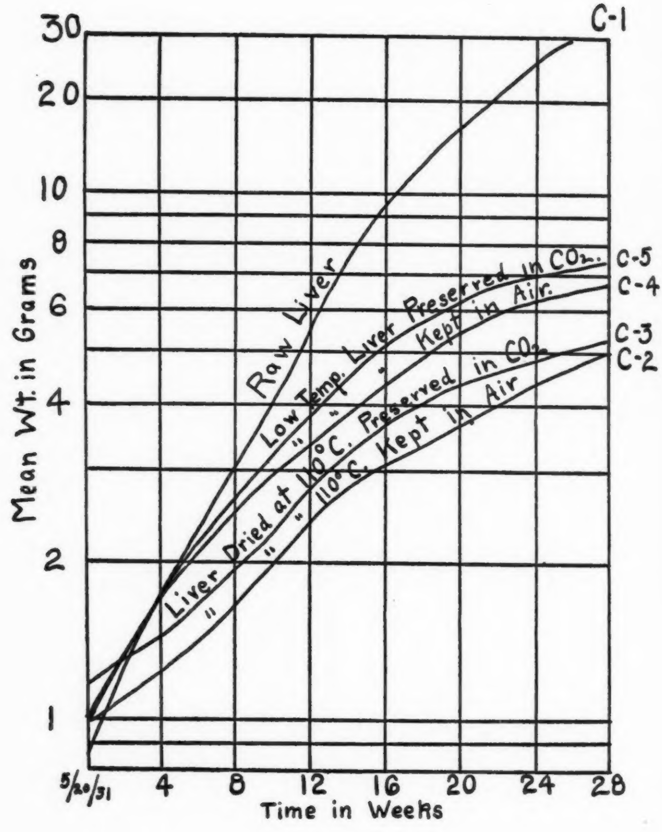

CHART 3

These growth curves show that low temperature drying and storage under carbon dioxide tend to preserve the factor H but in all these products most of it seems to have been destroyed in the course of the drying.

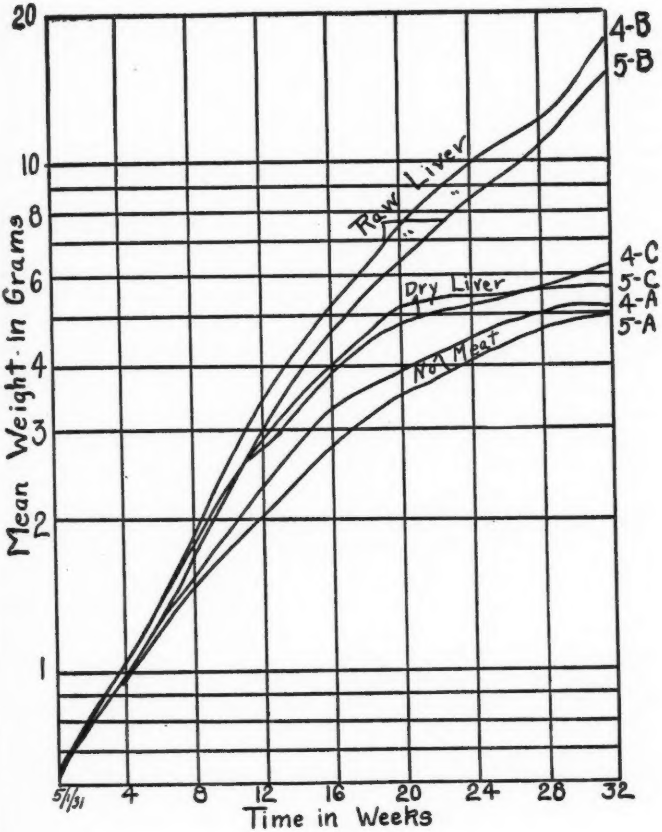

CHART 4

Growth curves of trout reared upon a mixture of equal parts of fish meal, dry skim milk and cottonseed meal supplemented with various forms of liver. The fish meal of diets 4 was a vacuum dried product while that of diets 5 was a special low temperature dried one. Diets A had no supplement. Diets B were supplemented with 25% of the dry-feed weight of fresh liver. Diets C were supplemented with an equivalent of low temperature dried liver.

In Chart 5 we have shown the growth curves from the B series of diets as well as Nos. 1 and 2. This series was designed to determine if liver could be dried upon dry skim milk in such a manner that it would retain its potency.

In the case of Nos. 1 and 2 we have more evidence that carbon dioxide tends to prevent oxidation and thus preserve the factor in meat. The superiority of No. 1 lies in the fact that is was preserved in carbon dioxide. In other respects previous statement that positive conclusions drawn from exthe two diets were the same.

The B series of diets shown in Chart 5 were designed with two different levels of dry skim milk. In one series B-6, B-3 and B-9 the diets are half dry skim milk and half liver when calculated to a dry basis. The remainder of this series was three-fourths dry skim milk and one-fourth liver on a dry basis. From our earlier experiments we knew that either of these milk levels would prove satisfactory if the liver were raw. On the other hand if some of the potency of the liver were destroyed in the drying this would be more likely to appear as a deficiency in the case of the lower liver level.

The liver dried at a low temperature and preserved in an atmosphere of carbon dioxide* proved as potent as the raw liver at both levels during the entire duration of the experiment covering a period of thirty-two weeks. Both diets B-5 and B-6 failed. Although the latter failed they might have considerable practical value since they proved very satisfactory during the first twenty weeks. This experiment illustrates our periments with trout covering a period of four months or less are of questionable validity.

In Chart 6 we have included the curves for two different experiments. Diets 91 and 92. They both consisted of equal parts of dry skim milk and dry beef liver. Both were canned in carbon dioxide and preserved until ready for use. The only difference between them consisted in the addition of ethyl alcohol to 92. Both carried trout through 48 weeks when 92 failed. No. 91 experiment was stopped at the end of sixty weeks with the trout in excellent condition none having been lost. A portion of this group is shown in the photograph.

It is interesting to compare this growth curve with that obtained exactly three years earlier (17). The earlier group was fed a mixture of dry skim milk 7, raw liver 90, cod liver oil 2 with the addition of a small amount of dry yeast. The two curves are as nearly identical as the errors of the measure-

*A patent application for this process has been filed in the U. S. Patent Office by D. K. Tressler.

ments involved permit. Hence diet 91 not only permitted growth during a period in excess of a year but it permitted as nearly as possible an optimum growth throughout this period. From these results we can conclude that it is possible for trout to show an excellent growth for a period of sixty or more weeks upon a dry feed alone with no raw meat. The comparison of the two curves, the data for the second of which was secured three years after the first is also of interest in showing the possibilities of duplicating results. Entirely different technicians were in charge of the feeding in the two cases.

The compositions of diets 80-84 are shown in Table 4.

TABLE 4

Diet No.	Cooked Starch	Dextrin	Cod Liver Oil	Dry Yeast	Fish Meal (1)	Fish Meal (2)	Fish Meal (3)
80	50	26	5	5	14	......	......
81	50	26	5	5	......	14	......
82	50	26	5	5	......	......	14
83	50	11	5	5	......	29	......
84	50	11	5	5	......	......	29

Fish Meal (1) was that of the Dehydration Process Company and the same as that used in experiment 4-A.

Fish Meal (2) was the special product made as described under diet 5-A.

Fish Meal (3) was the same as (2) except it was dried at 110° C.

Diets 80-84 were designed as assay experiments to determine if sufficient amounts of factor H existed in fish meals to allow normal growth in trout when they were provided with additional sources of vitamins A, B and D. Our earlier studies had indicated that trout utilize fish wastes to good advantage if some other source of factor H is provided such as raw meat. One might expect trout to thrive upon an exclusive diet of sea fish wastes but there are two possible errors in such a conclusion. In the first place these wastes do not contain the fish organs such as the liver, stomach and intestines. In the second place it is possible that trout are dependent in some peculiar manner upon certain plant or animal foods which they obtain normally either by direct consumption or by eating crustacea or insects.

Diets 80-82 were designed with very low protein levels. It was hoped to obtain marked growth differences in growth

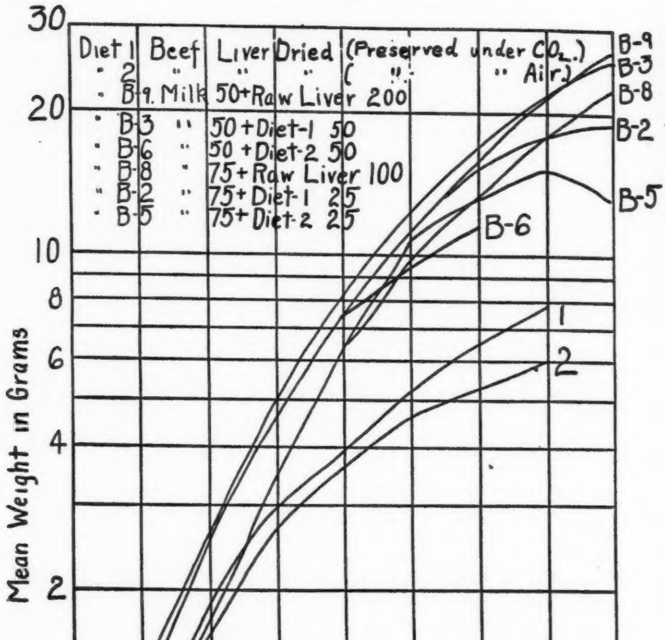

CHART 5

Growth curves of trout fed dry liver alone and liver dried upon a base of dry skim milk. Curve 1 for liver dried at a low temperature and preserved in carbon dioxide is superior to 2 where the dry product was in contact with air. Diets B2, B3, B5 and B6 were prepared as stated in the text by mixing the correct amount of dry skim milk and raw liver and then drying, yielding a final mixture such as that indicated on the chart. Group B-3 which received a dry diet made a growth equal to that of those fed raw liver mixtures. The curves indicate that an inert gas tends to protect some easily oxidized essential in the liver.

curves if factor H was present in one and absent in another fish meal. In Chart 2 even the very low protein level of 6 per cent yielded moderate growth. The 14 per cent fish meal diets with supplements of 5 per cent dry yeast would contain several per cent more protein, since the dry yeast contains 51-52 per cent.

The growth curves in Chart 6 for groups 80-84 are all subnormal. The higher fish meal diets permit a moderate growth

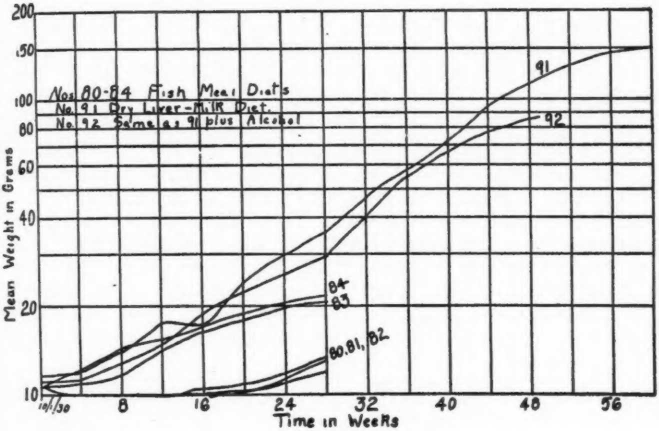

CHART 6

Growth curves of trout. Nos. 91 and 92 show the excellent growth of trout during a long time period when the trout were fed only the mixture of dry skim milk and low temperature dried liver stored under as a preservative put proved unnecessary. Curves 80-84 represent CO_2. Diet 92 contained 10% ethyl alcohol which was originally added attempts to assay the factor H in fish meal which seems deficient independently of the method or preparation.

for sixteen weeks while the 14 per cent diets gave poor results when compared with groups D-1-4 of Chart 2. These results show that trout utilize fish meal as a source of protein and calories but they also indicate the original products from which the meals are made are deficient in factor H. This confirms our earlier conclusions. No matter how well a product is processed it cannot supply an organic constituent that is lacking in the original raw material.

The Effect of Diet Upon The Chemical Composition of The Trout Body

Within certain limits the chemical composition of the bodies of higher animals depends upon the food consumed. The quality of the fat deposited in the depots of swine and most of the other higher animals depends upon the nature of the fat in the feed. A half century ago it was shown that a dog's body deposits mutton fat if the dog is first starved and then fed large quantities of mutton tallow. Konig (18) also found the body fat of carp varied with the fat fed. It is well established that the ash in the bones of animals such as rats and swine is considerably lower if the growing animal is fed a diet deficient in vitamin D or upon diets deficient in either phosphorus or calcium.

One of the questions that confronts the fish culturists is whether the trout reared in hatcheries upon artificial feeds are equal in strength to the wild trout that have grown to maturity upon natural feeds. Thus far no standards of "hardiness" are available by which one can evaluate the hatchery produced trout. These will undoubtedly be developed by the biochemist of the future. The two fields that are the most promising for attacking this problem are first, toxicology and second, studies of the chemical composition of the bodies of animals.

As one examines the composition of the diets commonly employed in the hatcheries such as raw meats, he is struck by the fact that they are usually very high in phosphorus and low in calcium. This introduces the possibility of some form of "rickets" in fish. Although various bone malformations have been reported in fish no one has furnished any substantial evidence that these are of dietary origin or are related to rickets as the term is usually applied. On the other hand, trout grow quite slowly in comparison to the animals that are subject to rickets such as swine. For this reason it is quite possible that they are able to satisfy their calcium requirements even upon meat diets.

It is also quite possible as we noted in our introduction, that trout can satisfy their calcium requirement by withdrawing calcium from the water in which they swim. As Dr. Davis (15) has noted it is quite possible that the conflicting results from studies of the nutrition of fish may be due to the variations in the soluble constituents of the waters in which they swim.

Sherman and Quinn (19) found that the rat body contains 0.34 per cent of phosphorus and 0.24 per cent of calcium at birth. These values gradually increase with age until the adult body contains 0.66 and 1.06 per cent respectively of phosphorus and calcium. These values were obtained upon the entire bodies of rats fed diets of milk and wheat which are adequate in both calcium and phosphorus. Pearse (20) found distinct seasonal fluctuations in the chemical composition of trout bodies when the quality of the diet remained constant. We are aware of few studies of the chemical composition of the entire bodies of fish and none that consider a relation of the inorganic constituents of the diet to this composition.

In a series of studies upon the growth of trout we employed diets that contrasted in their content of phosphorus and calcium. The diets used are shown in Table 5. Trout were placed upon these diets after they had attained a mean weight of ten grams and were fed upon them for the following thirty-eight weeks. They were then killed, the intestinal tracts removed and the entire bodies analyzed for moisture, fat, calcium and phosphorus. The iodine numbers of part of the fat samples were determined.

In these diets that termed "haddock flesh" consisted of the lateral muscles usually sold as fillets. That termed "bone loaf" consisted of the ground residue of the haddock after the fillets were removed. The bone loaf diets were very rich in calcium. The dry skim milk diet was also relatively rich in this element. All diets were high in phosphorus. In considering the effects of the various diets some regard must be given to the relative growth of the different groups. Group 2 which had been fed exclusively upon haddock flesh grew poorly. This is reflected in its high moisture content and the low value of fat. Under such conditions one might find the body relatively high in calcium since there had been only a very slow growth.

The highest values for both calcium and phosphorus were produced by the bone loaf diet. These values do not differ from the others sufficiently, however, to justify a conclusion that this group of trout may have had a superior skeletal structure. The entire bodies of trout contain only about half as much calcium and two-thirds as much phosphorus per unit weight as those of rats. From these data one must conclude that even upon diets relatively rich in phosphorus and poor in calcium such as those used in most hatcheries trout do not develop any disease that may be related to rickets. The iodine

TABLE 5

Diet	Mean Wt. gms.	Range in Wt.	H_2O %	P.E.M H_2O	Extremes H_2O
1. Beef Liver	58(20)	27-105	78.0(20)	0.48	73.3-81.1
2. Haddock Flesh	21(20)	5-45	81.5(20)	0.4	78.4-85.0
3. Haddock Flesh (75) Beef Liver (75)	77(20)	39-159	79.1(20)	0.4	72.1-81.0
4. Haddock (Bone Loaf)	54(20)	16-115	79.3(19)	0.2	75.3-81.9
5. Bone Loaf (75) Beef Liver (25)	78(20)	43-123	79.3(20)	0.38	73. -81.5
6. Haddock Flesh (66) Milk (33)	72(20)	33-150	79.8(19)	0.28	75.4-84.2

Diet	Fat (Ether) (Sol.)	P.E.M Fat	Extremes Fat	I. Nos.	P.E.M I. No.	Extremes I. No.
1. Beef Liver	6.14(20)	0.20	4.0-8.4	107(10)	1.1	93-119
2. Haddock Flesh	3.84(20)	0.21	0.62-5.9	96(11)	1.1	92-104
3. Haddock Flesh (75) Beef Liver (75)	6.50(19)	0.12	5.2-8.5	90(7)	1.1	84-94
4. Haddock (Bone Loaf)	7.1 (19)	0.20	4.4-9.2	105(6)	0.7	98-118
5. Bone Loaf (75) Beef Liver (25)	6.5 (19)	0.1	5.2-7.7	106(9)	0.6	103-111
6. Haddock Flesh (66) Milk (33)	6.27(19)	0.13	4.7-8.2			

Diet	Ca	P.E.M Ca	Extremes Ca	P	P.E.M P	Extremes P
1. Beef Liver	.486(13)	0.006	0.426°-.541	0.391(13)	0.005	0.318°-.422
2. Haddock Flesh	.556(13)	0.027	0.264°-.836	0.368(12)	0.013	0.237°-.538
3. Haddock Flesh (75) Beef Liver (75)	.418(13)	0.011	0.357°-.560	0.395(14)	0.012	0.325°-.550
4. Haddock (Bone Loaf)	.579(12)	0.016	0.480°-.709	0.420(12)	0.006	0.370°-.469
5. Bone Loaf (75) Beef Liver (25)	.447(7)	0.006	0.427°-.492	0.391(11)	0.009	0.327°-.466
6. Haddock Flesh (66) Milk (33)	.455(15)	0.005	0.397°-.503	0.387(16)	0.004	0.357°-.455

All analyses by methods of Official Analysis of A. O. A. C.

All values are on the original material on a wet basis.

numbers of the fats are similar in magnitude to those reported for other fresh water species (21). Since the milk in diet 6 did not lead to any increase in the calcium of the body we must conclude that the value of milk as a supplement for liver in the feeding of trout is due to some other quality than its calcium content.

Do Various Fish Species Have Specific Nutritional Requirements?

Although even Aristotle recognized that each animal species had its own nutritional requirements, this fundamental concept of biology is frequently disregarded by those who wish to introduce unwarranted generalizations into the field of nutrition. While some of our findings will probably have application in rearing various fish species, others of them will apply only in the case of trout.

In preceding reports (16) we have discussed the toxic action of linseed meal when used in feeding trout. In order to see if this feedstuff which is so highly valued by the farmer, is toxic to other species we fed it for a period of ten days to young bullheads, (Ameiurus nebulosus). This species will refuse to eat linseed meal alone but will eat it readily when mixed into a stiff paste with dry yeast. Bullheads seem unusually fond of yeast. Although feeding considerable amounts of this mixture of yeast and linseed meal for ten days we observed no symptoms that would indicate toxicity. We present this merely as a preliminary observation and as a method of inducing this species to consume feedstuffs that are not palatable. This experiment shows a contrast between two fish species.

Ultra Violet Light For The Treatment of Fish Diseases

In the introduction we have called attention to the recent studies in Germany in the radiation of fish. During the past year we have extended this promising work very little. Studies upon fish parasites cannot be made very well in connection with producing hatcheries due to the risk of epidemics that is involved. Ultra violet radiation is promising, however, because it is rapid in action, easily applied and tends to sterilize the water and troughs as well as the infected fish. Little data exist for judging its possible value for internal parasites. At the present time there is a growing recognition in the field of physiology that a beginning has scarcely been made in combining chemical therapy with such physical agents as ultra violet light.

During the past year an initial experiment was made in the control of gyrodactylus. During an epidemic, trout were kept in the same troughs. Half of them were radiated with ultra violet light while half were untreated. Those radiated seemed free from the organism while the others examined seemed to retain the infection. Since such investigations require the cooperation of physiologists and pathologists and since none of the latter were available, this work made little progress. It is reported, however, in the hope that the opportunities may be tested by some group working under more favorable conditions for the study of trout diseases.

SUMMARY

In a new series of feeding experiments with trout the relative values of a series of fresh meats were determined when they were used to supplement a mixture of two parts cottonseed meal and one part dry skim milk. Liver, lungs and kidneys were found to be slightly superior to heart and spleen although all proved potent. The minimum protein requirement for the optimum growth of trout is above fourteen per cent of the total calories. The growth upon the fourteen per cent level is almost optimum if the remainder of the diet is satisfactory. A simple mixture of calcium carbonate, bone meal and sodium chloride stimulated a slightly better growth at each of five different protein levels ranging from six to forty-two per cent. Trout fed low protein levels with a simple mineral mixture grow more rapidly but die more rapidly than those without the mineral mixture.

Several series of experiments indicate that factor H is destroyed when the dried diet is stored in air. Storage of the dried diet under carbon dioxide seems to preserve it. Calcium, phosphorus, ether soluble and moisture determinations were made upon the entire bodies of trout reared upon rations containing very different amounts of calcium and phosphorus. These values proved the same within the limits of the experimental error indicating that trout are probably able to secure enough calcium from a diet composed entirely of meat or possibly from the water in which they swim to build satisfactory bones. This throws considerable doubt upon the work of those who claim they have observed "rickets" in fish under natural conditions.

Two preliminary reports are given, one showing you cannot poison another fish species such as bullheads with linseed meal and another indicating that external parasites of trout may be destroyed by radiation with ultra violet light. No

differentiation has been made between the light waves and the effects of the ozone generated by the light.

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MARYLAND'S ACTIVITIES IN RAISING OF TROUT AND BASS

A. M. POWELL

Superintendent of Fish Hatcheries

Until a few years ago, like many other States, we were at a loss to know why we derived so little benefit from the plantings of trout and bass we were making in the public streams. We planted fingerlings and knew little of the conditions of the streams in which we planted them. We realized that modern transportation methods afforded the angler greater opportunities for fishing than formerly and there was consequently a greater drain on the streams. We also began to realize that planting larger fish would solve the greater part of our problem, but we knew that it would be impossible to stock every stream sufficiently to make it a worthwhile fishing stream. The Conservation Department finally ordered a stream survey, and for the past four years this work has been carried on in the sections of the State where the information was most needed. Unfortunately, this work has not yet been completed, but each year sees the completion of another section, and in a few more years there will be a dependable record of every stream in the State.

The stream survey thus far completed has disclosed a number of important things; first, it enabled us to learn definitely the condition of our waters which have been so long in doubt; second, by stocking only such streams as the survey showed to be suitable, we have saved thousands of dollars; third, by this saving we have been able to establish and operate to their capacity five trout hatcheries and two bass stations. In 1930 we planted 350,000 bass and crappie from four inches in length to seven inches in length, and stocked our trout waters with brook, rainbow and brown trout, none less than seven inches. In 1930 no trout were stocked of a less size than nine inches and there were thousands from twelve to fourteen inches. This work, which has been proceeding in a quiet way, has produced the best fishing the State has ever known and is attracting anglers from other States who return to their homes well pleased.

One of our department's greatest concerns in connection with its policy of rearing fish to at least legal size before planting in the streams is the high cost of feeding them. Various commercial foods were tried without success and we were always compelled to fall back on the liver diet. While

other foods could have been used, none produced the results obtained with liver.

On June 1st of this year we started to test out a prepared fish food from the Balto Laboratories, Wilmington, California, and so far we have obtained better results than with any food tried to date. Owing to the very limited time I have had to prepare this paper, it is impossible for me to give the detailed results from this feeding. However, 6,000 two-inch brook trout were placed in two concrete ponds, 3,000 in each. One lot was fed beef liver, and the other the Balto fish food (canned fish). Both ponds have been fed the same weight of feed and their needs generously supplied for one hundred and twenty days, beginning June 1st. The mortality in each pond has been eight fish. There is no noticeable difference in size or vitality of the two lots, both being very active and strong.

Aside from the fact that the trout thrive fully as well on canned fish as on liver, the waste in feeding the latter is eliminated, and the ponds are much cleaner in appearance than when the fish are fed liver. Moreover the price of this food is less than one-half the cost of liver and the food can be kept indefinitely without fear of spoilage, thus enabling us to keep a liberal supply on hand and also obviating the necessity of refrigeration, grinding, etc.

I might also add that in addition to using this feed for trout, we are feeding it to the small-mouth bass fingerlings, and they are thriving equally as well as the trout.

Discussion

DR. HUBBS: I would like to ask Mr. Powell what kind of fish it was that was canned?

MR. POWELL: It was canned salmon.

DR. HUBBS: Not the salmon eggs?

MR. POWELL: No, it was canned salmon flesh.

DR. HUBBS: What did it cost?

MR. POWELL: About six and three-quarter cents a pound delivered in Maryland.

DR. HUBBS: Was it a second grade of salmon?

MR. POWELL: No, California salmon, delivered in Wilmington.

PRESIDENT LECOMPTE: I am sure Mr. Cobb can give some valuable information with respect to that—they are feeding some kind of salmon in Connecticut.

MR. COBB (Connecticut): The feed spoken of in this paper is identical with that used by Mr. Titcomb in one of our hatcheries where it is impossible to get fresh meat. We were combining Silver Fur Food, put

up by Swift, with a little dried buttermilk. We were using the fish and also the Silver Fur, which was a meat preparation.

MR. FARLEY (California): What is the cost of raising these fish to nine inches or larger?

MR. POWELL: With the beef liver, thirteen cents a pound. The cost is about the same as Mr. Titcomb just quoted in his paper.

MR. FARLEY: I mean the cost of the fish per pound—the finished product, the fish to catch.

MR. POWELL: This is not authentic, although it is my own figure, our cost last year, as near as I could give it, was twenty cents a fish at nine inches.

MR. TITCOMB: Perhaps I ought to explain, with regard to getting at the cost of trout per pound, that it is a rather difficult proposition, owing to the fact that it is not easy to separate this year's crop from the crop of adults. In other words, you have a crop of fish coming on all the time, and without a great deal of expense and delay you cannot very well isolate your crop from the time it starts to feed until it is a nine inch trout—you have got all these other smaller fishes coming on the same time. I think, however, that Mr. Powell's estimate was fairly correct. It is about two-thirds of the price charged by the commercial trout dealers in the east.

THE BASSES OF ARKANSAS AND SOME EXPERIMENTS IN THEIR PROPAGATION

DELL BROWN

Superintendent, Fisheries Station Mammoth Springs, Arkansas

The State of Arkansas has an extensive variety of game fish, including most of the fresh water basses. The principal forms are the small-mouth black bass, (*Micropterus dolomieu*) found in the more rapid clear streams of the hilly sections; the large-mouth black bass, (*Micropterus salmoides*) found in almost every lake and stream in the state; and Kentucky or spotted bass, (*Micropterus pseudaplites*) found in the larger streams where there is some current and the water is fairly clear. In addition there is the rock bass or goggle eye, (*Ambloplites rupestris*) found in most of the streams of the state, but more abundantly in the streams in the hilly sections, and the calico bass or dark crappie, (*Pomoxis sparoides*) found in both streams and lakes in the central and southern parts of the state, but scarce in the smaller streams in the hills. To these must be added the white bass, (*Roccus chrysops*) inhabiting the rivers and clear sloughs, rarely in the smaller swift streams, and the yellow bass (*Morone interrupta*) found in the lower sections of the state. In addition to the above basses we have the white crappie, bluegill bream, strawberry bream, warmouth bass, and many other sunfishes.

Of the foregoing the small-mouth black bass, large-mouth black bass, Kentucky bass, rock bass, calico bass, bream and crappie are propagated at our hatcheries. Our annual output of game fish is approximately one and one-half million, about one half of which are black bass and we are able to rear about one-fourth million of the black bass to a size of 3 inches and better.

Along with our fish-cultural operations we have conducted some experimental work with the Kentucky bass. While this is not a new fish, it seems that only during late years have fish culturists recognized it as a distinct species. In view of this, I will give a few points about this fish learned during the past year at our hatchery.

This fish has been known by the fishermen of the lower White River for years as the small-mouth black bass and seems to be quite numerous near DeValls Bluff, Arkansas. I have never seen or heard of a Kentucky bass weighing more than two pounds. The color is much like that of the large-mouth,

only more spotted along the lower sides. The back is often more golden, and the shape is much like the adult of the small-mouth. In the station ponds the Kentucky bass spawns at about the same time and temperature as the large-mouth, depositing a smaller number of eggs. The growth of the young apparently is about the same as the other black bass, only the young grow more evenly in size and for this reason there is less cannibalism. In handling these fish we find they will not stand as much heat or mud as the large-mouth. This is the first season we have given this species much attention. While we have made all the observations possible, conditions may be different in other seasons and we will find other habits and characteristics. To date we believe that the one great thing in their favor is less cannibalism and their chief objection is their failure to attain the size of the black basses.

We are also doing some experimental work, trying to breed our fish up to larger size, as has been done with domestic animals. While we only started this work during 1930, and to date are only experimenting with the large-mouth black bass, we believe it both possible and practical to breed all of our game fish up and have a strain of larger fish. We hope to start with the bluegill bream this season.

We plan on breeding a largemouth black bass up for several generations by producing bass weighing one pound at an age of 8 months to one year, then taking the young of these over-grown bass, feeding and keeping the extra large of each generation for breeders for several years. It is believed in this way there may be produced for stocking our streams a strain of large-mouth black bass which will weigh two to three pounds when two years of age, where food is plentiful. It is also believed that this large fish would reproduce at a younger age than our present native fish.

During the season of 1930 we reared several hundred large-mouth black bass up to about three-fourths of a pound when 7 months of age. These fish were kept separate from our other fish and put into a separate pond. This past spring we took from these yearlings bass about 4,000 fry and put them into a two-acre pond. These young fish seem to be making a rapid growth with good food and we hope to have some of these fish large enough to produce fry next spring. In other words we hope to be able to get spawn from each generation as yearlings. If we are successful in producing a larger strain of the large-mouth black bass, it would seem that we could do some good work along the same line with some of the smaller game fish such as the bream and other sunfishes.

It is realized at this time that all who are connected with bass hatcheries are interested in rearing the young to large fingerlings size before planting. I will therefore give some of our experiences in rearing 250,000 black bass to 3 inches and better. We have experienced but little trouble in growing our young bass to two-inch fish, as they apparently will eat and thrive on crustaceans such as the daphnia, which we have been able to produce in great quantities.

When the fish reach about 2 inches it seems that they want and demand larger food and to date we have been unable to get a large proportion of the fish to take artificial food, such as packing house products or ground fish. They seem to want live minnows and if we do not furnish the live minnows they will eat their own kind. We have been growing the golden shiner for the young bass and find them very satisfactory. The only trouble we have is the inability to grow enough minnows.

After our young bass have lived on the minnows until the former have reached three inches about July 1 our minnows are about all consumed. It would seem that we need to grow enough minnows to feed our young bass another 3 months, until October 1. The weather at that time usually is cool enough to start distribution, and if our fish were well fed during all that time our bass should be from 5 to 6 inches in length. On account of the importance of the food supply we have about concluded that it will be found necessary to use two acres of ponds for forage fish for every one acre of fingerling bass in order to rear large bass in large numbers.

(Joint discussion of several papers begins on page 98.)

THE SPECIES OF BLACK BASS

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It gives me a great deal of satisfaction to take part in this group of papers on black bass. As some of you know, the bass referred to as Kentucky bass was not recognized by fish culturists or by scientific men until 1928. It was my privilege to be able to obtain some specimens of that bass and to observe that it was different from the large-mouth and the small-mouth bass.

It was something of a shock to realize that the long-established idea of two species of black bass was a false one, but the evidence was indisputable that there was a third species. I gave it the scientific name, *Micropterus pseudaplites,* and the common name of Kentucky bass. This was because the bass was particularily common in Kentucky, and I did not think of any other name that might be good as a common name. The adoption of that name, however, has caused a good deal of trouble, and I am very sorry I called it the Kentucky bass. The people in Kentucky seemed to like it, but Mr. Viosca down in Louisiana refuses to call it a Kentucky bass and says it should be the southern small-mouth. The name Kentucky bass does not go with the Ohio people, as they had some cross the river into the streams of Ohio. So perhaps it would be better to have another name for it. The common name in Ohio is yellow bass, but that is not good because there is another fish known as yellow bass.

The adult fish is characterized by the prominence of the spots along the lower side, and that characteristic is perhaps sufficient to warrant the common name of spotted bass. I do not know that it makes much difference what we call it, but it is very important that we recognize it.

It is important to recognize the species not only in fish culture but in the laws as well. That is not done now; practically all the laws of the states dealing with black bass mention only the large-mouth or the small-mouth bass, and it would be very easy for a man, if he were so disposed, to carry a case to court and make it impossible to convict him for any violation of the law with respect to the sale or handling of the spotted or Kentucky bass—whatever you may call it. That is a point which ought to be carried home by those who represent the states in which this particular species of black bass occurs. The name "spotted bass," or whatever name may

be decided upon for the species, should be written into the laws so that the species can be given legal protection.

The area in which this species occurs is a rather wide one. It does not go as far north as either of the other two basses. It goes farther south than the small-mouth bass. The states from which we have specimens—and I think the range of the species is well outlined by the specimens I have seen—are as follows: West Virginia, the southern parts of Ohio, Indiana, Illinois, Missouri, Kansas, (southeastern corner) Akansas, the eastern part of Oklahoma, eastern Texas, some parts of northern Louisiana, abundantly through Kentucky and Tennessee, Virginia on the Tennessee River side of the mountains. Mississippi, Alabama, Georgia, and South Carolina, I presume, because we have it from the Savannah River between South Carolina and Georgia. We recognize that it does not go quite as far north as the other two basses; we do not have it in Michigan or in the northern parts of Ohio or Illinois. It does not go so far south as the large-mouth, which penetrates into northern Mexico, but it does have a very wide range.

Regarding the range of this species and the common name southern small-mouth bass, suggested by Mr. Viosca, some complication arises in that the small-mouth bass is represented by a distinct species again in the mountain streams of Georgia and Alabama which are tributary to the Alabama River and in the streams on the Atlantic coast drainage. There is a form there which is more closely akin to the small-mouth bass than is the spotted bass, but is distinctly different from the ordinary northern small-mouth bass. That means that there are four species instead of two of the black bass in the United States. This fourth species, which has not yet a scientific name —I hope soon to describe it—has the very restricted range which I have outlined, probably occurring only in Alabama, Georgia, and South Carolina about the southern swing of the Allegheny mountains.

What additional species may be discovered in the future I do not know. It seems as though four ought to be enough, when we remember that there were only two. I have some bass specimens from southern Alabama which do not agree with any of these; what they are I do not know. They may be a hybrid; we get hybrid fishes, you know, quite frequently in nature. Hybrids among the sun fishes are very common; I know they are hybrids because I have proved it in experimental aquaria as well as through observations in nature

It was thought for a time that this spotted bass was a hybrid between the large-mouth and the small-mouth, but the

evidence now is distinctly against that viewpoint. The only evidence of hybridization of the bass that I have had is from a small stream in the southern part of Oklahoma. Of the bass found in that stream a few looked like the small-mouth and a few like this spotted bass, but the great majority of them are variously in between. But that is the only stream of scores from which I have seen specimens of spotted bass in which there is any real indication of hybridization, and the hybridization there is between the spotted bass and the northern small-mouth bass. There is a slight possibility that there is another species in that area, but I think it is a hybrid.

It may be that the large-mouth and the small-mouth bass do hybridize, but I have never seen one, and if any of you fish culturists ever produce any I would certainly like to hear about it, and preferably see specimens. I think we can assume that this spotted bass is not a hybrid; it has characters which are very distinctive and which are quite unlike those of either of the other two species.

There is some question further about the kinds of bass, even if we recognize these four species. The large-mouth black bass of Florida is very different from the large-mouth black bass of Minnesota. I do not think these differences are specific; they are racial differences, possibly what we would call sub-species; more likely merely local races. There is a very distinct need for a study of these races of black bass.

We all think, of course, of the giant black bass of Florida, which reaches a size far beyond that attained by the bass in any other part of the country. Is that black bass a distinct race, or does it grow large because of some inherent quality? Is it large simply because of the long growing season and the rich food found in the shallow lakes of Florida? That is something that is tremendously in need of investigation, and I trust that such investigation will be carried out so that we can improve our stock of black bass throughout the country.

(Joint discussion on several papers appears on page 98)

STUDIES ON THE KENTUCKY BLACK BASS

(*Micropterus pseudaplites Hubbs*)

JOE W. HOWLAND

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In 1927 when the paper on the Kentucky black bass, *Micropterus pseudaplites Hubbs* appeared, much comment was aroused over the situation. It did not seem feasible that this new species of bass could exist in a group so well known as the black basses. To the unpracticed eye the fish was naturally included with the large-mouth bass, perhaps more on the basis of coloration than of form and structure Dr. Henshall in his treatises, "Book of the Black Bass" and "More about the Black Bass," mentions unusual basses existing in southern waters in Mississippi and Texas, which, although showing marked similarity to the other black basses, might be a new species. But by a series of obscure argumentations the question was dropped, and from then until the paper by Dr. Carl L. Hubbs appeared on the description of the new species, no mention of it was made. At the present time data have been compiled on this species sufficient to confirm Dr. Hubbs' statement that it is a new form. A definite ecology, life history, breeding habits, etc., point out a new species so definitely that there is no doubt as to its validity.

The name "Kentucky Black Bass" which was applied to the new species by virtue of the state in which the type specimen was taken, has met with some disapproval, chiefly because of the wide distribution of the species. Hence it is one aim of this paper to suggest a new name, which, to the mind of the writer and others concerned, is more characteristic of the species. This name, "Spotted Bass", or "Spotted Black Bass," taken directly from the rows of spots regularly arranged along the side of the fish, the pronounced spot on the operculum, and the spot on the caudal, seems more applicable in every way than does the original term, "Kentucky Black Bass."

In the paper by Dr. Hubbs definite locality records were mentioned in which the fish had been recorded for the following states: West Virginia, Ohio, Indiana, Kentucky, Georgia, Alabama, Louisiana, Kansas, Arkansas, Oklahoma and Texas. To these states have been added the following regions: Mississippi, Tennessee, Missouri, Virginia, Illinois, in

Ohio to within 20 miles of the Pennsylvania line, and in Georgia immediately across the South Carolina line. This presents a definite area of distribution in which practically all of the states possessing the fish are represented. Throughout this entire area the fish shows the definite species form, and as far as is known, identical behavior.

In a consideration of morphology, only those factors concerned with an easy identification of the fish will be mentioned here. The marked characteristics which distinguish it from the other basses are as following: (1) the above mentioned rows of evenly arranged spots on the sides of the fish below the dark lateral band; (2) a distinct dark spot at the base of the caudal fin which remains through adult stages; (3) the very definite dark spot at the tip of the operculum which contrasts itself more strongly in coloration than in the other two basses; (4) a marked "pike-perch" build, the impression being given by the length of head and the raciness of body; (5) the spiny dorsal fin with a much more conspicuous rising curve than in the small-mouth, but not cut off from the rest of the fin as in the large-mouth; (6) the anal fin with 9 or 10 soft rays, this not agreeing with either of the others; (7) the pectoral fin with 15 rays, this also not found in either of the others. By a close consideration of the fish in order to mark the above characters identification will be made easy.

The ecology of the fish will be considered as it exists in southern Ohio streams, but little being known of it over the entire distributional area. For the purpose of convenience and clarity it can be divided into ten different points, each of which will be stated briefly.

(1) The bottom is made up of broken down sedimentary sandstone characterized by the absence of boulders.

(2) The region varied from rolling to hilly, the hills being made up of sandstone, in some cases mixed with outcroppings of limestone and shale. A most excellent index of the spotted bass habitat in this state is, however, the absence of a pure limestone structure. Where this exists it is of a lower type and is eroded and broken down quite easily.

(3) The type of stream goes hand in hand with the region involved. The streams are sluggish, the fish ascending then only as far as this condition remains. In faster pools, if they inhabit them at all the bass are found in deep water where the current does not affect them greatly.

(4) The lack of vegetation is important. In cases of lime-

stone formations where water willow does appear, the scarcity of spotted bass is noted.

(5) This fish inhabits deep water, this factor being illustrated by the abundance of them taken on trot and set lines placed in the water.

(6) Closely associated with depth of water is shade. When the fish is taken in shallow water, the stream is densely shaded, while if taken in deep pools, shade is not a potential factor. The absence of light is important. Fishermen say that this fish is more often taken at night than either of the other basses and it is certain that nets, trot lines and set lines, do take more of this species than of the other two combined.

(7) The water inhabited is usually quite turbid, the condition of the substratum being such that the water is in a more or less roily condition most of the time. This factor is also connected with the light factor which in general may be the reason for preferring this type of stream.

(8) The selection of a southern situation which is more closely associated with warmer water is noticeable in Ohio streams. This appears to be one of the dominant limiting factors which prevent the widespread distribution of the species.

(9) In all of the streams where the fish was taken the more mature condition of the drainage was quite evident. The associations with the fauna of more sluggish water found in such mature drainage systems stands out clearly.

(10) The food of the species, as far as can be determined, is the equivalent of the small-mouth, being crayfish and minnows. One must avoid calculation in food studies when two such varied forms as crayfish and minnows are concerned, as the minnow is digested quite readily, while remains of crayfish may stay in the stomach for days.

In the spring of 1931 approximately 60 breeders ranging from 8½ to 14 inches in length were secured from fishermen and placed in a hatchery at Newtown, Ohio near Cincinnati. It was the intention to attempt small-mouth hatchery methods with them, and at the start of the season, this was carried out. However, due to the scattering of the young fish from the nests at a very early age, it was impossible to capture all of them. As a result the experiment evolved into a comparative study on large and small-mouth hatchery methods as applied to this fish.

From the total number of breeders that survived, twenty-four to be exact, seven nests were built, the average nest varying between those of the small-mouth and large-mouth

to a great degree, the majority favoring the small-mouth type. Eggs developed on three of these nests, the total number of fry per nest varying from 2,000 to 2,500 on the whole. The females observed depositing eggs were all around 9 to 10 inches in length (tip of snout to caudal base), the males for the most part, slightly larger. The eggs hatched, one nest in four days, one in five days, and one unknown.

From three to four days after hatching, the young were observed rising off of the nest. These were then collected to the best of our ability and placed in a rearing pond filled with algae and weeds, the date on which the transfer was made being June 3. From this time on they disappeared and it may be concluded that the fish were injured in the transportation from one pool to another. Again it is reasonable to suppose that the fry were removed at too early a stage, so that the chance of survival inhibited by the injury in handling, was very slight indeed. To remove the fish at a later state would be virtually impossible, as one week after hatching they start to scatter out so that the securing of them is not at all feasible, both from the view of labor involved, and results obtained. The use of retaining screens might prove possible, but this too involves a comparative increase in labor.

The adult fish were transferred from the breeding pond and the fry reared by the large-mouth method. Natural food abounded in great numbers, and when the fish reached the approximate length of one inch they were started on ground fish and fed twice daily from then on. This was first ground very fine, and as the fish increased in size, ground coarser. It was noted that the fish did not grow with the rapidity of the small-mouth fry in the other pools of the hatchery. The feeding manner of the fry resembled the small-mouth in every respect from the time when they were learning to take the food until feeding had been actively established. The fish thrived remarkably well, and exhibited no tendencies toward cannibalism in any degree. This is undoubtedly due to the even growth rate which graphs show to be much more constant than that of the other basses.

The small-mouth method, in regard to the crop of fingerlings produced, is totally unsatisfactory. Hence it might be stated that except for experimental purposes only, the large-mouth method is the best type to use.

The fry are more active than either the large or small-mouth fry, reaching this stage earlier than either of these, swimming constantly after the four or five day stage. They circle around the nest in a wide circle diving back on it for

shelter if frightened. In case they scatter widely and are over another nest when frightened they will dive for it instead of the home nest. In this way great numbers of them are often observed hovering over old nests in the pool.

The male bass does not make moves to conduct the school of young fish. As soon as the fish are hatched he moves off of the nest remaining in the immediate vicinity, but not over the nest. He does not beat the young fish down by the movements of his fins as does the small-mouth. The male was observed to leave the fry at different times. In one case he left them when they were about five days old, while in the other two cases he stayed with them until they became approximately a half-inch in length.

Hence all results taken from the propagation experiments show that the fish is easily reared, and due to its ecological habitat, the only practical fish for stocking numerous streams of the type mentioned before.

The economic and propagational importance of this species is much more marked than it might seem. Distinct advantages of the species assert themselves which make it very valuable both in the wild forms in the streams, and the breeders in the hatcheries. The value of this fish must be recognized when one considers it as the only bass that inhabits certain types of water; that it has large numbers of young of remarkable activity; that there is a constant size in the young; that there is a short hatchery period; that it has a fighting ability of no mean sort; and that the fish may have a breeding period before it becomes of legal length, eleven inches.

The ease with which it can be cultured is shown by the results in the Ohio hatchery, and also in the federal hatchery at Lonoke, Arkansas, where remarkable results have been achieved. Its hardiness might be illustrated by an example at the Ohio State Fair of 1930 where two dozen fingerlings were on display. These showed no signs of sickness, while both small and large-mouth fingerlings became fungused to a great extent. No actual record as to its gameness and fighting ability is available, but fishermen in southern Ohio regard it as a much harder battler than either of the other basses with respect to sizes.

It is the purpose of the Ohio Division of Conservation to stock this fish in the streams of southern Ohio to which it is favorably adapted. Plans are being made for this in 1932, but at present the breeding stock is being built up. The result of the experiment remains to be seen.

In conclusion it is feasible to declare the fish is not a hybrid: (1) on account of its constant morphology between specific extremes, not constant in either of the other recognized basses; (2) its definite ecology and distribution; (3) its breeding habits and behavior; all of which point to a new species. It has a definite economic importance and fills a niche in the conservation programs of all the states concerned. It is of untold value in the new principle of stocking fish in their natural habitats, as compared with the old way of dumping them at random. It must be remembered, however, that it can be used only in a definite way and to a definite purpose. If used in this manner there is no doubt as to very satisfactory results.

(Joint discussion on several papers appears on page 98)

THE SOUTHERN SMALL-MOUTH BLACK BASS

Micropterus pseudaplites Hubbs

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The least known of all game fishes, but best appreciated when once you become acquainted with him, is none other than our *Micropterus pseudaplites Hubbs,* the small-mouth supreme of southern spring-fed waters. In addition to its many other qualities and charm, this creature is literally bedecked with diamonds from stem to stern, and should be recognized at once as the "King of Diamonds" of the finny pack.

The structural features of the new bass have been amply described by Hubbs with one notable exception, which from the standpoint of one who studies his icthyology with fly rod and frying pan, is all important. The villiform teeth in both jaws are longer than in either the large-mouth or the northern small-mouth, and in addition, there are two conspicuous patches of similar teeth on the tongue, one on the forward portion, and one situated just above the third pair of gill slits. To me this structural difference is indicative of more trout-like habits than either of the other two species of black bass. This feature is borne out by observation, the fish always lurking behind some log, root or other obstruction in swift water, ready to dart after and seize its prey with a firm hold and return as rapidly to the spot from whence it came. Here, it proceeds more leisurely to swallow its prey, which if large or insecurely held, may be released and snapped up again in a position more convenient for the act of swallowing.

These tactics make *pseudaplites,* from the angler's standpoint, the most alluring fish of the southland, for, if fished for with gentlemanly baits, the number of escapes is relatively high and it takes some real angling to increase your percentage.

Unfortunately I am not in a position from personal experience to compare, in the wild state, the southern small-mouth with its northern relative. Between it and the large-mouth, whose geographical range it occupies in part, and which it is supposed to resemble superficially, the difference is as day and night. Less headstrong but more pluck, less inertia but more agility, less bulk but more streamline, less bulldog but more

whippet, it is the bass antonym of the large-mouth.

Both species may be found in the same streams but seldom side by side. As our spring-fed rivers come down to the sea, we find in succession three stages. First the swift water section with bars of gravel and coarse sand. Then there is a shorter section well above tide level where they widen and deepen and the current slackens perceptibly. In this section, the over-burden of gravel and coarse sand stops but there are still some bars of finer sand. Next comes the lower flood plain where only clays and silt are carried, and which is so near tide level that it may be affected by very high tides. It is in the second section only that we find the two species in any sort of competition. Above that it is all *pseudaplites,* below, all large-mouths.

Even in the overlapping zone, the competitions is not keen, each species keeping to his own habitat. Where the current, however slack, sweeps against the bank, we find the one; where there is a large dead water area as on a flat covered with cow lilies, we find the other. If, even in the swiftest section of the stream, you find an oxbow lake, all you can catch in the lake are large-mouths, in the stream, *pseudaplites.*

The accompanying drawing Fig. 2 shows the characteristic external features of the fish better than words can tell. On the dorsal side of a line running from the center of the eye to the center of the tail, the fish is studded with a series of more or less diamond-shaped dark markings, which tend to but never quite form a definite symmetrical pattern. The larger complete diamond markings cover an average of nine scales each, but these markings are often incomplete or obscured. The lowest row of these diamonds is super-imposed upon a dark lateral band similar to that found in the large-mouth, giving it a saw-toothed edge, particularly along the upper side, thus presenting a different appearance from the lateral band of the large-mouth.

Below the lateral band, the ground color pales into white, not brassy or yellowish as in the large-mouth. Each scale here possesses a distinct darker spot, the upper five or six rows of which are more or less connected into bands giving it a resemblance to the belly of the striped bass.

The eye is larger than in either of the other two species of black bass, this being noticeably so in the young. This might indicate that it ordinarily seeks its prey in deeper waters. This suggestion is borne out by some observations, which it must be admitted are as yet inconclusive. Deep fishing

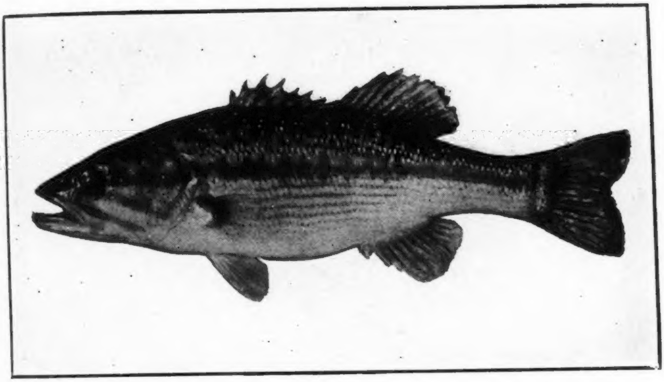

FIG. 1

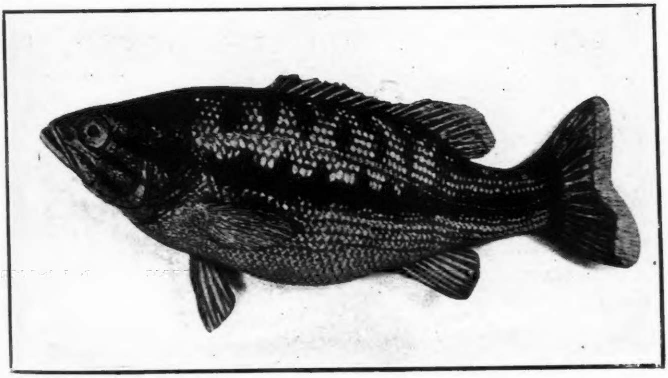

FIG. 2

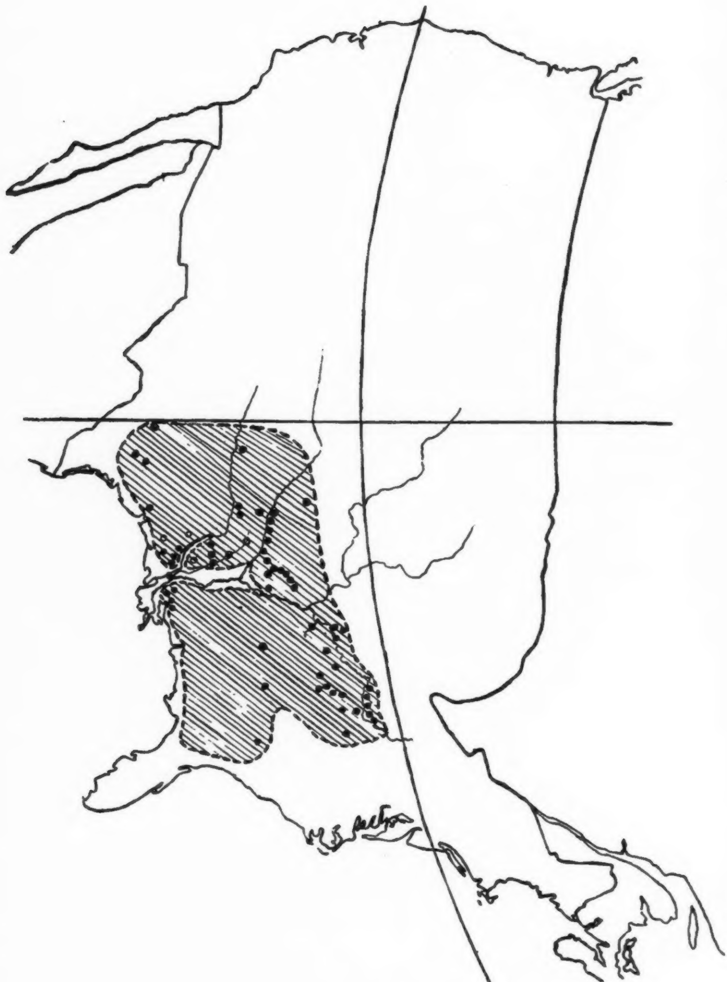

FIG. 3

Fig. 1. Photo of *Micropterus pseudaplites*, the most alluring fish of the southland.

Fig. 2. The "King of Diamonds". Pen drawing of a well marked typical *pseudaplites* from a fresh caught fish in fighting pose, showing the chief external features used in identification. Note the small mouth, large eye, the sawtoothed upper edge of the lateral band, the diamond-shaped markings on the back, and the rows of spots on the belly. The light tipped tail, so characteristic of the young, rarely shows as clearly in the adult as it does on this specimen.

Fig. 3. Map illustrating the distribution of *Micropterus pseudaplites Hubbs*. The dots indicate authentic records, the circles unverified reports. The shaded area indicates the approximate geographical range, so far as at present known. It will be seen that the range occupies roughly the southeastern quarter of the United States, including the Gulf of Mexico drainage north of Mexico and Florida, east of the one hundredth meridian and south of the fortieth parallel; and the Atlantic drainage of Georgia. It is absent from the tide level portions of rivers flowing into the gulf of Mexico, and from the sluggish bayou and lake portions of the Mississippi Valley. The locality record shown in the southern Mississippi Valley was of two specimens taken while the phenomenal flood of 1927, which mixed up our fishes generally, was subsiding. (After Hubbs with modifications).

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certainly brings a larger string of bigger fish than surface or fly casting, especially if one lets his lure play around sunken logs near the bottom.

The eye of *pseudaplites* always has a decided reddish-orange cast when the fish is first landed. This is rarely the case with our southern large-mouth, so the layman can immediately distinguish the two by this means as soon as they are brought to the surface of the water.

Although the adult is heaviest, somewhat as with the other species of black bass it is surprising to find the young of much more slender build, and with its prominent large eyes, resembling the walleye pike in appearance. The body however, seems to thicken more in proportion to depth as it grows, developing a more perfect streamline form, in contrast to the more laterally-compressed, pot-bellied adults of the other two species.

Except for the occasional exception which proves the rule, the expert angler can usually tell which species he has hooked, even when fishing in a section of a stream where both are found. The rush and strike usually without breaking water, the darting to and fro in the swift current, the effort to wrap your line around a fallen branch, or to disappear in a deep pool, all make up a fish story different from that of the large-mouth bass.

The breeding habits of the southern small-mouth seem to be essentially like those of its northern congener. It spawns on gravel bars in the spring, but in South Louisiana, later than the large-mouth. In captivity Mr. J. C. Forsythe at the Beechwood hatchery near Alexandria, Louisiana, has reared them under my direction for two generations. They were much more shy in the still water of the breeding ponds than were the large-mouths, and only during the second year did the brood stock become sufficiently tame to come to the shoreline to be fed. Both young and adults loved to accumulate in large schools near the intake pipe. The water supply used was from a spring-fed stream in which these fish thrived naturally.

The southern small-mouth does not seem to grow as large as either of the other two species, at least as far as records go. I have seen numbers of them weighing around 2½ pounds. Martin L. Close, of Alexandria, whose identifications I have every reason to accept as accurate, reports that he has weighed specimens as large as 6¼ pounds from the upper reaches of that river.

Little can be added to the knowledge of the distribution of Fig. 3 of this species from my observations, except to define its range in Louisiana. East of the Mississippi it is found in all running streams of the Florida Parishes from the Pearl to the Amite, including all their tributaries above tidal influence. West of the Mississippi and south of the Red River, it is abundant in the upper Calcasieu and all its tributaries, as well as all other spring-fed streams originating in that general vicinity. It probably occurs in the Sabine, but I have only indirect evidence to that effect. North of the Red River it occurs in a number of spring-fed streams coming down from the Arkansas border, notable Dorcheat, D'Arbonne, and tributaries of the Ouachita.

It is absent from all lakes, from the sluggish streams and bayous of the Mississippi, Atchafalaya and Red River Valleys, and from the sluggish portions of spring-fed streams flowing into those valleys or into tide water. There has only been one notable record which stands as an exception to this rule, two specimens having been taken by me in a small stream west of Lottie, Louisiana, Point Coupee Parish, shortly after the flood of 1927. This great flood which had no doubt mixed up our ichthyology generally, had not quite receded, the Atchafalaya levees were still down and there was a swift current flowing through a small slough into Bayou Close.

Only in one section of the state do I know of spring-fed streams in which the large-mouth is the dominant species, viz., those flowing into Catahoula Lake, Lasalle Parish. In that vicinity there are hundreds of square miles of regularly flooded swamp lands, perhaps the finest large-mouth breeding territory in the country. Upon the subsidence of every flood, large-mouth bass rush into those streams by the hundreds of thousands, and virtually wipe out the food supply and no doubt prey upon the young of both species.

Discussion

PRESIDENT LECOMPTE: The papers on the basses by Mr. Dell Brown, Mr. Howland, Dr. Hubbs and Mr. Viosca are now open for discussion.

MR. TITCOMB: May I suggest that Mr. Brown's paper on fish culture be discussed separately from the others?

MR. DELL BROWN: I think the suggestion is all right—it doesn't make any difference.

PRESIDENT LECOMPTE: Then we will discuss Mr. Brown's paper first.

MR. TITCOMB: The reference Mr. Brown made to the rapid growth

and getting the fish to breed the first year is an interesting one. It leads me to inquire whether he considers the rapid growth has affected the maturity; in other words would the smaller yearling bass breed at all?

MR. DELL BROWN: They did not this year. We put the smaller of the same age in a pond adjoining the larger, and the larger pond hatched; the smaller did not.

MR. TITCOMB: That confirms my theory about the trout. In other words, trout which have grown rapidly mature much more quickly than those of slow growth. About the 250,000 bass, were those large-mouth or small-mouth?

MR. DELL BROWN: They were large-mouth, and the Kentucky, of course. Ninety per cent of them were large-mouth.

MR. TITCOMB: What kind of minnows were used?

MR. DELL BROWN: Golden shiner.

MR. WICKLIFF: I would like to ask the fish hatchery superintendents how many have been able to get large-mouth and small-mouth to spawn at the age of one year?

DR. WIEBE (Iowa): I just want to confirm the observation made by Mr. Brown, that the large-mouth basses will spawn at the age of one year, but it is only the exceptionally large specimens that will do so.

MR. COBB: May I ask Mr. Brown whether he fed these fish other than the natural food, the golden shiners, up to certain sizes?

MR. DELL BROWN: Daphnia, and then the golden shiners. We tried to feed them artificial food; probably five per cent of them took it, but the others would not take it.

MR. COBB: What was the artificial food?

MR. DELL BROWN: Ground fresh carp.

MR. TITCOMB: Did you feed them in your regular feeding ponds, or put them in smaller ponds?

MR. DELL BROWN: They were fed in one acre ponds.

DR. WIEBE: I have tried a number of times to get the small bass fingerlings to take food out in the pond, but they do not seem to be much interested. But I have had several small lots of both small-mouth and large-mouth in tanks that take artificial food very readily. That food consists of shrimp bran and whitefish meal in equal proportion.

PRESIDENT LECOMPTE: What size tanks?

DR. WIEBE: About six feet long by twenty inches.

PRESIDENT LECOMPTE: They take the food readily there, whereas they will not do so in the open.

DR. WIEBE: They do not do it in the open. The same is true of the larger fish. I have a number of large-mouth, six to ten inches, from the Mississippi river that take the same food readily, but they do not take it off the pond.

DR. DAVIS: With regard to feeding bass in ponds, I stopped at the Hackettstown hatchery the other day and Mr. Hayford had been having wonderful success feeding small-mouth on ground fresh salt water fish. He simply takes the fillet, grinds it up and feeds the fish in the ponds. They come rushing up when the feed is put in, and now he has small-mouth bass fingerlings from four to six inches long in wonderful condition. The ponds are heavily stocked, and they are fed very largely on this ground fish. They are fingerlings, hatched in June.

MR. WICKLIFF: I suggest that when reference is made to artificial food, the particular type of food be specified. In Ohio we have been feeding ground fish; there is a special report on that particular subject to be given here. For instance, it seems to me that to call fresh ground carp artificial food would not be giving the carp due consideration. Therefore when you talk about artificial food you should distinguish between natural food and freshly ground carp and goldfish and such dried products as are used at the hatcheries.

MR. E. SURBER (Wisconsin): I should like to ask Mr. Brown and Mr. Wickliff how they arrive at the fact that this Kentucky or spotted bass is less cannibalistic than the large or the small-mouth?

MR. WICKLIFF: The growth curves show a more uniform growth rate in the Kentuckies than in the large or the small-mouth. Moreover, observations made by the observer in the pond did not indicate cannibalism.

MR. MURPHREE (Oklahoma): May I ask Mr. Brown whether he compared the number of spotted bass that can be raised in the rearing ponds with the number that can be raised of the small-mouth.

MR. DELL BROWN: I have not compared them with the small-mouth, but I have with the large-mouth—the same number of fish, the same size pond, and the same attention.

MR. MURPHREE: With what results?

MR. DELL BROWN: The Kentucky varied but little in size, but in the large-mouth there was a great variation in size.

MR. MURPHREE: The same number in proportion to pond area?

MR. DELL BROWN: We have not drawn the pond yet this year, and I cannot say. I know there is a great difference in the size, and I believe a great deal more cannibalism in the large-mouth than there could possibly be in the spotted.

MR. MURPHREE: We have had a few of these spotted bass in our hatchery for the last seven or eight years—what you call the Kentucky bass. I find that they get along among themselves for the first six or eight months much more agreeably than the large-mouth bass do. I have a stock of spotted bass at the hatchery now. I had always thought that the two basses we have in Oklahoma were small-mouth, until this year we got two of these spotted bass that would weigh about four and a half pounds each. I called them small-mouth and the man

at the hatchery said: "No, that is not our small-mouth." The spotted Kentucky bass is in a good many of our streams and has been for years. In the majority of the streams he does not enter the rapid water as the small-mouth does.

MR. HOGAN (Arkansas): Dr. Wiebe has said that he has fed bass in troughs and that they take the food readily. I would like to know the number of fish he has raised in concrete troughs, and how much he has fed them.

DR. WIEBE: We have not really done anything of that sort. The fish I mentioned have been used for experimental work that I hope to report on before this program is finished. They were simply retained so that they could be observed for the effects of the treatment they were being subjected to; we have never seriously tried to rear fish that way. While I am on my feet I should like to encourage those gentlemen who profess that the spotted bass is not cannibalistic and grows more uniformly to keep up their good work and see if that is really true. In some years we get large-mouth in a certain pond that are very uniform in size. I think Mr. Thomas stated the same thing about some fish at the hatchery in Kansas. On the other hand, this year we have a pond in which there are only a few fish—seven adults, in fact; we take a sample of these fish every month and we find that as fingerlings they are extremely uniform in size. Now, that may happen in some years, while in other years it is quite different. It certainly is not true of the majority of our large-mouth or of our small-mouth this year. Therefore I would like to encourage these gentlemen to keep up their work, and to be sure to include a sufficient number of fish in their study and continue it for a sufficient length of time to be certain that the condition they are dealing with is a reality.

MR. PHILLIPS (Texas): Reference has been made to a good many different kinds of bass; I think I can now give you another one. Five or six years ago our little town was very much excited about some blue bass being caught. Of course the boys who caught them thought they were about twice as game as the ordinary black bass—a good deal stronger, fought longer and all that kind of things. I took my fly rod and caught five of them. This was in an area of impounded water that had been used by a mill that was cutting a lot of gum for the purpose of making boxes—fruit boxes. Well, I caught five blue bass; they were just as blue as if they had been immersed in a strong concoction of indigo for a week. At first I was a little puzzled, but it wasn't very many minutes before I saw from all the evidences one would ordinarily look for that it was a large-mouth bass. The boys thought I was all wrong; they were sure it was a blue bass. The only reason I could give them for the coloration of this fish was found in the sweet gum stumps that were left in the pond where they had cut the timber. My idea was, and still is, that there was an exudation of some coloring matter

from the stumps which caused the peculiar coloration in the fish.

Some years ago in West Texas I was fishing on the north fork of the Llano river. It is a swift stream fed by springs, and I suppose the temperature of the water was about 75 degrees, which is pretty cool for Texas. I caught some bass there, and I was satisfied that they were large-mouth bass, but they were long, slim fish; they seemed to have lost all their aldermanic proportions. Everybody said they were a different kind of bass, so I sent some of them to Dr. Henshall, and of course the Doctor said they were large-mouth bass. He still sticks to the idea he has advanced for years, namely, that the environment will produce the type. These fish were in swift water, and they had to swim like the dickens in order to make a living. Therefore they were not chubby, but they were the big-mouth bass just the same.

PRESIDENT LECOMPTE: Before we begin the discussion of the other three papers I would like to ask Mr. Wickliff a question. I believe he said that the sportsmen of Ohio refuse to acknowledge this species of bass as the Kentucky spotted bass. I suppose the sportsmen of Ohio are very glad to catch that species and recognize it as a distinct variety even though they do not admit the name "Kentucky bass" because they are in the state of Ohio.

MR. WICKLIFF: The so-called Kentucky bass is found only in the extreme southern part of Ohio, and the fishermen there like the name "Spotted bass" because of his spotted appearance. Personally they have no objection to "Kentucky bass," but because of its widespread distribution, the fact that it occurs in southern Ohio and other states, it seemed to them, and to us also, that the term "Spotted bass" was a better name for the species than a name which would seem to restrict it to one state.

PRESIDENT LECOMPTE: I do no think you got my point—it is the same species of bass, whether you admit it is a Kentucky bass or not.

MR. WICKLIFF: Exactly.

MR. TALBOTT DENMEAD (Washington, D. C.): Mr. Chairman, before we proceed with the discussion I want to state that the question of whether there are more than two species of black bass is an important one to the law enforcement officers. Most of the states have laws protecting bass worded very differently Some of them read "Black Bass;" others read "Small-mouth and large-mouth black bass," and there are some states that actually protect the black bass under the name of trout, or green trout. It seems to me that under most state laws a defence that the bass was another species would be a successful defence. The federal black bass law, which was passed in 1930, was prepared and drawn up as it now stands in my office. The law states specifically, small-mouth and large-mouth black bass, and gives their scientifis names —*Micropterus salmoides* and *Micropterus dolomieu;* it does not protect the spotted bass or any other species. So far as we are concerned, therefore, the matter of identification is important. If the spotted bass

is a separate species the federal laws and a great many of the state laws would not cover it.

President LeCompte: Mr. Denmead has raised an important point. I am sorry to learn that the law which we worked so hard to get, known as the Hawes law, applies only to the small and large-mouth black bass. The laws of Maryland provide protection on the black bass, large and small-mouth, and all other species of bass, which amply covers the situation. It seems to me that the state laws and the federal law should be so worded as to cover all species, because if the scientists are going to bring in five or six new species of black bass we shall soon find that we have no protection on any of them except two, the large and the small-mouth.

Mr. Wickliff: Would Mr. Denmead think it advisable for the various states in the future when they revise their fish laws to insert the scientific name of the fish as well as the common name?

Mr. Denmead: I have had a good deal of experience in endeavoring to secure the passage of fish and game legislation, and I have found that the average legislature has no particular interest in the scientific names, but if you can designate in your law the fish or game by its common as well as its scientific name you unquestionably will have much more enforceable law. I would approve of it if the legislature is sufficiently educated to pass it with the scientific names.

Mr. Quinn (Alabama): I just wanted to ask Dr. Hubbs, in reference to that fourth bass which he described as having been found in Alabama, Georgia and South Carolina, if that is the species locally known down in east Alabama as the red-eye?

Dr. Hubbs: I would think it might very well be so called because he does have a very bright, red eye, in life.

Mr. Quinn: I am wondering if the so-called Kentucky bass is what has been referred to as the Illinois bass, found in lake Martin.

Dr. Hubbs: I think not. I think it also is the species referred to as the red-eye bass or Coosa river bass.

Mr. Quinn: We have the large-mouth and the small-mouth and still another in lake Martin. If that is a separate species from the Kentucky—some of them were found in the State of Illinois and were designated for convenience as the Illinois bass—then we have still another species in Alabama. That rather complicates Mr. Denmead's law.

Dr. Hubbs: We have had quite a number of specimens from Alabama, and from these specimens it appears that you have the large-mouth, of course, and you have the spotted bass, which I call Kentucky bass. Then you have this unnamed species, the Coosa river bass, you might call it, or Alabama bass. The Coosa or red-eye bass is very much like the northern small-mouth, although the average angler probably would not differentiate them.

MR. QUINN: It is commonly known in northeast Alabama as the red-eye.

DR. HUBBS: That name, red-eye, is also used for rock bass in a large section of the country. It is used in Missouri and Kansas for the spotted or Kentucky bass also, I understand. It also has a red eye, although perhaps not as bright a red as this southern small-mouth bass of Alabama.

MR. QUINN: I think it is common knowledge that many of our fishes, if not all of them, possess what the scientist calls the quality of protective coloration. The bass along the coast in brackish water—all along the gulf coast and I suppose along the Atlantic coast too, are greenish in color, corresponding to the color of the water, and they take the name of green trout. In the lakes and swamps of southwest Alabama, where there is a tremendous amount of decaying vegetation, you find the fish contiguous to the brackish waters very black in color, and in the adjoining waters, especially in the fall of the year, they will take on a greenish color. This may be contrasted with the Texas blue bass.

MR. WICKLIFF: I think we are all agreed as to the scientific names. The common name, however, will be one thing in Ohio and another in Louisiana, and so on. The common names will be different, but the scientific names will be the same.

MR. THADDEUS SURBER: Our laws in Minnesota are permissive; any species not mentioned specifically in the game laws, whether bird, fish or mammal, is protected. I would like to ask Mr. Denmead how many states have laws based on the permissive feature.

MR. DENMEAD: I am sorry I cannot answer that question right now. Of course if you have a permissive form of law which allows you to fish for only two species, the other species, if any, would be protected. It is in effect in a number of states, but I cannot say offhand how many.

MR. T. SURBER: I think that would simplify the enforcement of the bass law, both federal and the state. In Minnesota we have had a law on the statute books which has not permitted the shipment or sale of bass of any kind, so that we fall right in with your scheme for taking care of interstate shipments. But I just wondered as this discussion proceeded whether that thought had occurred to many of you—whether or not your laws were permissive or the contrary. If they are permissive, then you can take care of the situation; if they are not, it will have to be a matter of legislation, in which case you will have to be careful to apply the right names to the fish you have in mind, because basses are known by myriads of names in different parts of the country.

MR. BURR (Texas): May I ask Dr. Hubbs with regard to the locations in which the spotted bass are found in east Texas? We have just completed two fish hatcheries, one of them near the Louisiana line. Another question: If they do not remain in schools and could not be taken

into a trap, would it be better to raise them in the brood ponds, and would cannibalism be too severe to make it a success?

DR. HUBBS: As to methods of propagation, I think someone else, possibly Mr. Brown, who has had experience in propagation of species, would be in a better position to answer. I do not remember the actual point at which the species was taken, but they are in the eastern half of the state and not in the Rio Grande. I remember one record in the Colorado river, and I think two or three of the streams in the vicinity of the Colorado river flow into the Gulf. I would expect it to occur in most of the streams north of the Rio Grande and around about the Louisiana border.

THE PROBLEM OF EFFICIENT MANAGEMENT OF HATCHERIES USED FOR THE PRODUCTION OF POND FISHES

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The production of fish is a business, and the utilization of a dozen establishments for the production of fish is a complicated business. The fact that the operation of this system of hatcheries is one of the functions of state government adds to the complications, for in the affairs of state government, there is always an auxiliary function whose importance may actually exceed the obvious one. Under these conditions the problems of management become positively bewildering, and the present paper deals merely with a few of the problems encountered in an approach to the task of attempting to attain some efficiency in the operation of such business.

The management of this system of fish hatcheries involves, besides the actual production of fish, the modification of the existing physical equipment as well as the development of new projects, and no inconsiderable share of the expenditures is necessarily directed toward making the hatchery properties worthy objects of public pride. Under these conditions the production costs per fish appear to be excessive, and it is only by increasing the efficiency of operations that we can hope to justify the capital investment and running costs. Of necessity the taking of accurate records is essential to any system of management, and the study of these records should yield information on the efficiency of management. The success of the business is properly gauged by the cost per fish produced, and management of a system of hatcheries involves manipulation of the personnel and equipment in order to make it yield the maximum production of a satisfactory product, at a minimum cost per fish.

The Ohio Division of Conservation possesses a series of twelve pond-fish hatcheries of which three are being used for the propagation of bluegills and catfish in 1931, while the other nine are being used for the production of fingerling large-mouthed and small-mouthed black bass. The hatcheries have been located variously about the state and since Ohio has sufficient range in latitude to present a considerable difference in climate between its northern and southern parts, certain of the hatcheries have recognizable climatic advantages.

The southermost hatchery is the one at Newtown, near Cincinnati, and the northernmost one is at Chagrin Falls, near Cleveland. The last killing frost in the spring occurs about a month earlier at Newtown than at Chagrin Falls, and in the fall the first killing frost gives Newtown another month's advantage. This means that the fish at Newtown have a two months longer growing season than the fish at Chagrin Falls, and the advantage is perfectly obvious in the fish produced. It means also that breeders can be transferred from the colder northern hatcheries to Newtown after the dangers of a late cold spell at Newtown have passed, but before the breeders have reached the ripe condition in the north.

In the twelve hatcheries there are ninety-three ponds with a total water area of about forty acres, and their cost to the state has been about $350,000. The expenditures for their operation in 1930 amounted to about $80,000, while the budget for 1930 allows about $76,000. Since no expenditures can be made otherwise than through headquarters, the costs of operations can readily be obtained, but the recording of hatchery operations constitutes a real problem. The taking of accurate records seems to the hatchery man a major evil if he tackles the job seriously, or an inconsequential affair which can be attended to later when the memory is vague, if he does not. However, no progress can be indicated without landmarks, and, without comparison or contrast, facts lose their significance. Satisfaction with the production of a "lot of fish" indicates an incomplete comprehension of the job, and accurate records must be made, willingly or otherwise.

Each hatchery must be considered a unit when trying to improve the operation of the system, and each pond must be considered individually when trying to increase the efficiency of the hatchery as a whole. At the present time each pond's complete seasonal history is being recorded, and this data are to be used in improving the productivity of the individual ponds from year to year. Weekly reports are submitted. showing the daily food consumption of each pond, the weight being obtained on small accurate Fairbanks platform balances. A monthly temperature sheet shows the daily weather and water conditions, and uniform thermometers are used at all of the hatcheries. The graphs of the water temperatures for 1930 show correlations of cold spells with the recorded loss of eggs. Losses of fish are reported by telephone or telegraph, and the repetition of last year's epidemics of Ichthyophthiriasis and Cyclochaetiasis have been forestalled this year by prompt action in isolation and treatment.

There are three purposes to which the bass ponds need to be put, namely, spawning ponds, fingerling rearing ponds and yearling rearing ponds. Production is based upon the output of the fingerling rearing ponds, so that all efforts should be directed toward reducing the areas assigned to the other two purposes to the minimum requirement in order to increase the area available for fingerling production. Per pound of food used, the smaller the fish, the greater the resulting growth attained, so that the longer the fingerlings are kept in the ponds the less value we are receiving for our investment in fish food. Moreover, if we hold and feed fish a second year this reduces the harvest to a biennial crop and multiplies by two all attendant costs.

Within our eight breeding ponds with their total area of 4.14 acres we used 1,494 breeder large-mouthed, small-mouthed, and spotted bass. The number of breeders used per acre of pond ranged from 90 to 662, and the best results were obtained from 430, although it is probable that this ratio in a smaller pond is more effective than it would be in an acre pond. The small average number of fry obtained per breeder in 1931 may be attributed to various causes, of which late cold spells is probably one of the most important. To prevent losses from late frosts it is planned to modify the spawning ponds, install spawning compartments, and perhaps use electric heating units within the compartment on chilly nights. However, it is also true that the condition of the breeders is a major factor, and it happened last year that we were unable to stock the breeder ponds in the fall with the desirable number of minnows and crayfish. To make adequate provision for the coming winter eight fish ponds were leased and stocked with breeder goldfish from Lake Erie. The young goldfish should be from 2½ to 4 inches long by November first, and it is planned to place an abundance of them in the ponds with the breeder bass before the freeze-up.

During the spring of 1931 an attempt was made to obtain a broodstock of small-mouthed black bass from Lake Erie for use in one of the hatcheries. Two hundred of them were transported by fish car from Sandusky to Columbus, and taken the remaining twenty-five miles by truck to the London Hatchery. Another one hundred were brought all of the way by truck, and all of the handling was done by our own men, who know something of the care required to avoid injuring the fish. Of these three hundred only thirty-five survived the first thirty days in the hatchery pond and not a single fry was obtained from them. This has not been the invariable ex-

perience, but it is the usual one and no funds will be wasted in this way in 1932. To provide a domestic stock of breeders, the largest of the 1930 fingerlings of both species were carried over and are expected to serve as breeders in 1932 and in 1933, for in this region large-mouthed bass spawn in their second spring while the small-mouthed bass spawn for the first time in their third spring. We have 1,700 of these yearlings on hand this year and they occupy two ponds which have an area of 2.2 acres. By making similar annual reservations, an ample broodstock can be maintained.

The best record of production obtained in 1930 was made by a pond at the Newtown Hatchery. This pond has an area of .55 of an acre, and it was stocked with 30,000 small-mouthed bass fry. The pond was drained 158 days later, and the harvest consisted of 16,000 fingerling bass weighing 1,199 pounds. On this basis the optimum number of fry to add to an acre of water is 55,000, and the maximum productivity per acre is 29,090 bass having a weight of 2,181 pounds. In the bass pond utilization in 1931 there are 48 rearing ponds which have a total area of 22 acres. To stock these according to the ratio indicated above 1,200,000 fry were needed, whereas actually we obtained only about one-third of this number. By the use of the above formula we also can calculate that the maximum possible productivity of our 22 acres of rearing ponds would be 639,980 fingerlings weighing about 24 tons.

At each of seven hatcheries three basins were built during the spring of 1931, and the production of the entomostracan, *Daphnia magna,* has been inaugurated into the Ohio methodology. Each culture basin resembles a big concrete bath-tub, its size being twenty by six by two feet. As it is filled the water is passed through scrim or silk bolting cloth, and an average depth of one foot is established. Allowing for the rounded corners there are about one hundred cubic feet of water in each basin, and to this we add, using the recipe of Dr. G. C. Embody, six quarts of sheep manure and one quart of superphosphate. An inoculum of the organisms to be cultured is added, and some boards are floated to provide shade, for it has been noted that excessive light or heat will destroy a culture, though ordinarily the entomostracans may be seen swarming in the patches of direct sunlight, avoiding the shade. After about three weeks crustaceans may be dipped out daily and placed in the fry screens or rearing ponds, and a culture may be made to last six to eight weeks by the periodic addition of more fertilizer. When the seasonal need for this

kind of food has passed, the basins are scrubbed out and for the balance of the season they are used as live boxes.

Various kinds of food have been utilized, and our most satisfactory results have been obtained as follows: as the small-mouthed bass fry begin to rise from each bed they are enclosed in the spawning compartment by slipping the screen into place, and the fry are fed within these compartments for about two weeks. At first they are provided with the small native entomostracans, but after about a week they are able to take the larger *Daphnia magna*, and this is supplied in abundance from the culture basins. After the fry have been placed in the rearing ponds, they are still fed the large Daphnids, and when they are about four weeks old they are offered finely-ground fresh goldfish. Goldfish are bought in quantity lots at two cents per pound from the Lake Erie fishermen, and these are trucked alive to the hatcheries where they are kept alive until they are dressed and put into the food grinders. This food is offered to the bass fry nearly continuously, particularly in the region of the intakes where there is a little current, and in a few weeks the fish have formed the habit of getting their food in this manner. Coarse vegetation in the fish pond is a source of great trouble at this time for the fish hang back in it and do not readily become domesticated.

When the young bass flock to the feeder, their food can be changed to our advantage, for after this they will take fish that have been frozen, and instead of carrying only about 750 pounds of live fish at a time our little trucks can carry from one to two tons of dead ones packed in ice, and this materially reduces our trucking expenses. From this time on the goldfish are placed in cold storage in several distribution centers, and small lots of them are taken at short intervals to the nearby hatcheries. It is our ambition to have electric iceboxes at each hatchery, but this may not be realized in the very near future. The bass feed readily on this frozen goldfish and we aim to keep them supplied with this one kind of fish, for we have found that they cannot be readily changed from goldfish to suckers or other species, and will apparently go off their feed when this is attempted. Suckers and herring are just as satisfactory as goldfish providing only the one kind of fish is used without change. Canned carp and canned marine food (Balto Food Ration) were tried but did not give satisfactory results.

The distribution of fish in Ohio has been based upon the application system, whereby the fish are placed in the hands of local sportsmen and wardens for actual planting, and for

some reason or other, while using this system the public fishing has grown worse rather than better. To improve the effectiveness of fish distribution the following steps are planned: (1) the adoption of the system of numbering streams used by the New York Biological Survey, and its application to all of the streams of Ohio; (2) the immediate utilization of this system of designation in stocking records; (3) the eventual compilation of data about all waters by the use of existing records of our Bureau of Scientific Research, of the State Board of Health pollution records, and of records supplied by the game protectors; (4) the eventual replacement of the application system by a system of stocking based upon this file of data; (5) the use of tags upon a small proportion of the fingerlings distributed each year.

The problems of personnel are probably not dissimilar in Ohio from those of other state systems, and they are of such importance as to merit considerable discussion. The duties of a fish hatchery superintendent are varied and rather technical, so that the longer a man remains in service the more valuable he becomes until age limits his activities. He needs to be ingenious, capable of devising and building new equipment, and it is essential that he be able to serve as plumber, steam-fitter, carpenter, concrete worker, tinsmith, and ditch-digger as the needs arise. We also expect him to be a bookkeeper, and he should be able to use a microscope on occasions when disease organisms raise havoc. Besides these and other varied functions, he must know fish, and how best to meet their various needs so they will thrive and grow and breed, and then he should know the geography of his region, and the ecology of the streams in order that the fish he has raised may be placed where they will possibly be able to gratify some angler's wish for a fighting biter. During the open weather season he keeps busy from sunrise to sunset, and during the winter he has to pretend to be busy to salve his own conscience and avoid our criticism. Aside from his job with the state there is practically no market for his specialized services, so that he is apt to stick regardless of how inadequately the state fulfills its obligations as an employer. The things the hatchery man really wants of his employer are: (1) A task to be loyal to with clear definition of his duties and responsibility; (2) Appreciation of capable loyal service, and a sense of security against change for any other reason; (3) Remuneration adequate to permit communal respectability; (4) Opportunities to attain increased responsibilities and pay; (5) Assurance of provision for his old age.

When these conditions can be met as any employer ought to meet them, it is probable that the problems of personnel will in large measure be solved.

To modify the existing hatchery ponds and to design new ones which shall be more satisfactory, it is desirable to know (1) The optimum size and shape of breeding pond, with the most desirable breeding conditions for each species of bass; and (2) The optimum size and shape of pond for rearing by the methods outlined.

Although the number of bass fry per breeder obtained in 1931 seems low the best average (870) was made by smallmouthed bass and the nature of this pond appears to have advantages. It has an area of .32 of an acre and is roughly rectangular in shape. It was formed in the spring of 1931 out of two smaller ponds by removing the separating levee, and the barrier was only reduced to give a depth of one foot of water. Along this ridge in the pond bottom a series of lumber stalls were constructed opening both ways towards the deeper water, separated by a partition down the middle. The outer ends of the stalls were slotted to receive fine-meshed copper screens, and a board running along the sides of the stalls was low enough to reach into the water. A board platform ran the full length of the series over the middle partition making observation and manipulation very convenient, and the boards down the outside assisted observation by stopping all waves. Gravel for beds was placed in each compartment and thirty-six of the forty stalls were actually utilized. The only flaw in this pond was in the easy grade of the bottom which made it possible for the fish to nest outside of the spawning compartments, and it is planned to remedy this by making steep drop-offs all around.

The typical Ohio fish pond is nearly square in shape with a surface area of from one-fourth to three-fourths of an acre. The margins drop quickly to a depth of from two to four feet, and the bottom grades gently to a depth of five to six feet before the penstock or overflow. Water is introduced through a six or eight inch iron pipe, either directly from the supply pipe-line or by the overflowing of an adjacent pond, and in some cases both are provided. After the pond has been filled the flow is reduced to little more than enough to keep it full, replacing loss by seepage and evaporation. Excess water is allowed to escape through the penstock, and the pond level is determined by the height of the boards inserted in the pen-

stock grooves before the drainpipe. An independent overflow may permit drainage of excess water to an adjacent pond.

New rearing ponds to be constructed will differ radically from the old ones just described. They will be of two types, very different from each other and these will be for distinct methods of pond-fish propagation. One type will be adapted to the rearing of bass from the fry to the fingerlings stage by provision of extensive fertile shoals where fry should find food abundant, and by feeding of ground fresh fish from that time on. These ponds will be only 60 feet wide and from 300 to 600 feet long, for it has been found that in narrow ponds of this type the fish will learn to follow the feeder around the pond and the opportunities for each fish to eat its fill are vastly increased.

A pipe line along the head ends of a series of ponds of this shape will carry about 250 gallons of water per minute under pressure, and any volume up to this full amount can be directed into any one pond of the series at a time. This is an advantage when the young bass are just learning to feed, for it has been found that they can be taught to take artificial food more easily where there is a little current and this current can be provided with this sort of a water supply. Having the current entering at one end of the pond will also prevent the stranding of fish when the pond is being drained, and will serve to flush out the pond bottom when thorough cleaning seems to be desirable. Also it has been found that an adequate flow of water will prevent the spread of infectious diseases and parasites. The shoals of a pond of this shape will be more extensive per acre of impounded water than in ponds of any other shape, the minimum being, of course, the circle.

The second type of rearing pond will be large, of five to fifteen acres in area, and this small lake will be used like a small lake, differing only in that it will be completely drainable. Natural conditions will be simulated in an effort to establish the complete cycle that is necessary to turn inorganic bottom material into the fish species we desire. Aquatic plants will be encouraged, for the minute forms that thrive upon them are links in the food chain, and various species of crustaceans and insectivorous small fish will be introduced, and adult bass, bluegills, rockbass, croppies, will be added. In the autumn the pond will be drained and the season's crop removed and planted, while the brood stock will be returned to the pond to function another season.

Discussion

MR. TITCOMB: Mr. Langlois spoke about the difficulty of getting enough fry. It might interest you to know that Mr. Beeman, of Connecticut—I think the only commercial small-mouth bass breeder in the world—has devised a new method of taking fry off the nests. He uses a brass tube about six feet long and one inch in diameter, with a reduction in the size at the mouthpiece. He locates and marks the beds of the bass in a reservoir where fishing is prohibited. When the fry have hatched he syphons the bass off the nest and moves them to his rearing pools.

He does that now in cooperation with our commission, because we have control of the fishing there and can say whether he can remove these fry or not. I do not know whether you would have the same conditions in other states, but in Connecticut fishing in municipal reservoirs used for domestic water supplies is prohibited. While we utilize these reservoirs as a breeding place and move the adult fishes, we are now using this discovery of Mr. Beeman's to remove the fry of the bass. It is not a difficult matter to get several hundred thousand fry out of one of these reservoirs in that way and avoid the carrying of brood stock.

MR. RODD (Ottawa, Canada): Mr. Langlois said that in the spring of 1931 he took steps to avoid the losses of 1930. Would it take him too long to tell us what those steps were?

MR. LANGLOIS: Not at all. In 1930 the white spot disease got started in one of our bass rearing ponds at Newtown. It started this year in another pond at the same hatchery and we lost approximately a thousand fry. We drained the pond, dipped the fish in a strong salt solution for forty-five seconds, transferred them to a large, concrete basin nearby and kept them there for about four days. Out of the 25,000 fry we put in the pond, we estimate we salvaged about 19,000 of them; our losses seemed to stop as a result of that treatment. We transferred them to another hatchery, put them in rearing ponds, and the losses stopped, apparently as a result of the salt treatment.

MR. TITCOMB: Did you feed them during the four days?

MR. LANGLOIS: Yes. They were about six or seven weeks old

MR. RODD: The ponds were not again used?

MR. LANGLOIS: No. That pond we filled with water and treated very thoroughly with copper sulphate; it was left idle for the remainder of the season. At the other hatchery last year the little protozoan Cyclochaeta got in and completely cleaned out one pond and did some damage in another. I should add that last year after that pond was cleaned we drained it and left it exposed to sunlight for a week; then we filled it and had no more losses that season. As I say, this year

Cyclochaeta appeared again in that same pond, and our losses started at a dozen or fifteen a day. We drained the pond and again used the salt treatment. This batch of fish got two salt baths. We had constructed a series of Daphnia pools along the lowermost level and could flow the water in each of them. We filled these three Daphnia pools; as we took the bass we treated them, put them over into the Daphnia pools, held them there for twenty-four hours, gave them another salt dip, put them back in the pond, and our losses have stopped. We have not lost any more.

THE PROPAGATION OF BLACK BASS IN INDIANA

WALTER SHIRTS

Superintendent of Fish and Game

The Indiana Division of Fish and Game now operates five hatcheries for the propagation of small-mouth and large-mouth bass, rock bass, crappies, bluegills, red-eared sunfish and channel catfish, yellow perch and pike-perch. Three of these hatcheries are located in the lake region in the northern part of the state, one in the central and one in the southern part.

The propagation of fishes, especially black bass, began in Indiana as long ago as 1908. The problems of pond culture were then attacked not by the state, but by a small group of sportsmen in Indianapolis, among them George N. Mannfeld. After many discouraging failures and few successes, practical methods were eventually found. It was not, however, until 1913 that the state established its first hatchery on the insistence of these same sportsmen.

METHOD

The bass spawners are held over winter in an earthen pond. Minnows for feed are placed in the pond in the late summer and fall. All ponds not used for wintering adults are allowed to remain dry during the winter. In March these ponds are treated with hydrated lime to overcome acid conditions in the bottom and to kill larvae of objectionable insects. Spawning ponds are then prepared by placing nest boxes. For small-mouth bass the boxes are filled with gravel and for large-mouth with dried and beaten sods placed root side up. The ponds are then filled. The spawners are removed from the winter ponds and placed in small holding ponds fed by spring water and are held there until the water in the spawning pond reaches a temperature of 65 to 70 degrees. This usually occurs in early May. The adults are then paired off for spawning in ratio of five males to seven females, to lessen the danger of fighting among the males. The paired fishes are then placed in the spawning ponds. After the fry are hatched the nests are cribbed and fry distributed to rearing ponds.

With species other than black bass, such as rock bass, crappies and bluegills, the spawning and rearing is in the same pond, and the nests are not cribbed. The channel catfish fry

are removed from spawning ponds and placed in rearing ponds. They are fed with ground fish, crawfish, beef hearts and liver.

Fertilizers to produce crustaceans for feed in the rearing ponds consist of horse and sheep manure introduced shortly after filling the ponds with water. Menhaden fish meal is used from about the time the fry are hatched until the No. 1 stage, about 300 lbs. to the acre, usually in 3 applications.

Distribution of the fishes starts at the 1 in. stage and continues throughout the summer. Bass shipped in August and September will be from 2½ in. to 5 in. in length, although we have sometimes reared a few large-mouth to 8 in. or 9 in. in four months by intensive feeding. Before delivery the fishes are held over night to harden in holding tanks supplied with spring water. Deliveries are by motor truck and the plants are usually made by our messengers. For transportation 10 gallon cans and 5 gallon pails are used. While we accept applications from clubs and individuals we also select the water to be stocked and no applications are filled where water is unsuitable.

Cooperative Rearing Ponds

There has been much recent agitation in the state among sportsmen for the establishment and operation of rearing ponds and many organizations have expressed a desire to experiment therewith. A few such ponds have just recently been put into operation, but it is too early to learn what the results will be. In order to encourage this movement, this department has announced the following plan for next season: The department will furnish fry for rearing ponds which have been constructed according to its specifications and supervision and will pay a fixed amount of money for rearing the fry to fingerlings, that is to say, $20.00 per thousand for No. 2 fingerlings black bass, $30.00 per thousand for No. 3 and $40.00 per thousand for No. 4 and larger; the fishes, of course, to remain the property of the state and to be planted in suitable public waters. It is also proposed that the organizations, instead of receiving fry from the state, stock their rearing ponds with breeders and thus raise their own fry. No schedule of prices has been fixed for this other than to base them on our own cost of production. It remains to be seen whether the organized sportsmen will fall in for this plan and if they do, what the results will be.

Difficulty In The Use of Lake Water

In the propagation of black bass I might mention one interesting fact, which seems to be established in our experience and that is that it is practically impossible to raise small-mouth bass by pond culture in lake water in Indiana. At any rate, our two hatcheries which use lake water only have consistently failed with small-mouth while the three hatcheries using water from springs or flowing wells have good success with this species. We have not attempted to seek a scientific reason.

Other activities include removal of predatory fishes from infested waters; the rescue of fishes from receeding waters; scientific studies of the foods of fishes, in co-operation with Indiana University; and a survey of trout waters in the state for the purpose of determining their suitability for that species and the practicability of stocking the same, this likewise in co-operation with the University.

THE FRESHWATER FISHES OF MISSOURI

JOHN H. ROSS

Game and Fish Commissioner of Missouri

Our problems in Missouri are probably the same as those which confront the majority of states in the union. It is not so much the question of production of fish as a question of providing suitable food and environment in the streams to ensure their reaching the adult stage. With all the states we have been compelled to adopt a policy of raising the fish to larger size before they are released.

The rainbow is the only trout we propagate artificially. We have two rainbow trout hatcheries, one located at Bennett's Springs, a spring flowing more than one hundred million gallons of water a day, and one at Sequiota, near Springfield, with a capacity of twenty million gallons. The fish, which as I say, are raised to catchable size before they are released are placed in the state parks—Montaugue State Park on the headwaters of the Current River, the Roaring River State Park which is just across the line from Arkansas and Bennett's Springs Park near the central part of the state.

We produce a great many more rainbow trout than are actually required. Our rainbow trout water is limited and the spring branches are short. The Current provides about twenty miles of trout water, the Roaring River about seven, Bennett's Springs a mile and half and Montaugue, which is the largest trout stream in the state, about twenty miles.

The large and small-mouth bass are our native fish. We take great pride in the waters of the state, comprising more than eight thousand miles, suitable for the basses. There are about fifteen miles of fishing streams in the state outside of the Missouri, Mississippi and Ozark Rivers.

As I said a few moments ago, I believe our great problem is the condition of the streams after the fish are released. Not more than half a century ago the hills were covered with forests, the ground was covered with leaves, and the waters resulting from the rains moved slowly to the streams. That is changed. After a heavy rain the water rushes off quickly, and much of the natural food in the streams is destroyed. Consequently there is very little natural food in many of the streams in the central states.

Our problem, then, is that upon which many of the states are expending money with respect to which they are gaining much valuable information—the supplying of natural food in

the waters. In the majority of streams in the Ozark hills all that is left for the fish to eat is their own kind. Practically all the vegetation has been covered, the old swimming hole is filled, the streams are only one-fourth the size they used to be and naturally the fish are becoming cannibals in order to survive.

It appears from the discussion that the small-mouth bass is an easy fish to raise. That is not the experience we have had; in fact we have had more trouble with the small-mouth black bass than with any other fish we have raised in the state. We find that we can propagate the large-mouth successfully in large numbers but we do not have as much success with the small-mouth black bass.

Game fish are protected and those taken in Missouri cannot be sold under any circumstances. If they come from outside the state they may be sold as long as they comply with certain size requirements.

A COMPARISON OF THE NATURAL AND ARTIFICIAL PROPAGATION OF SALMON

R. E. FOERSTER

Biological Board of Canada

To introduce for consideration the question of the value of and benefits derived from artificial propagation of salmon as compared with natural propagation may appear to many as the unearthing of a well-gnawed bone of controversy, but it must be remembered that there is still lacking that definite, concrete, scientific information on which an argument should be properly based. Consequently in reporting further results of a fundamental research into the problem a discussion of the subject becomes necessary.

The attitude of fish culturists, in the main, is well known. They are convinced that artificial propagation is vastly superior to the natural process. Many scientists, however, who are interested in the conservation of our fisheries but who are quite impartial toward the various propagational methods, are still skeptical of the romantic picture painted by the practical fish-culturist and are not yet convinced that the picture is actually a true portrayal of the facts. For this, incidentally, they have been roundly accused of partisanship toward natural propagation and of being impervious to argument favoring artificial methods.

It is freely admitted that there are undoubtedly certain situations where artificial propagation of salmon has been successful and certain circumstances or conditions that make, in certain areas, the practice of this method desirable but broadly speaking such instances are but isolated cases. The fundamental principles governing the practices of both natural and artificial propagation have, until recently, been overlooked and before warranted decision is justified a definite survey and study of these fundamental factors is required.

An outline of the investigation into the natural and artificial propagation of sockeye salmon at Cultus lake, British Columbia, was presented before this Society in 1928. Further illuminating records are now reported.

The methods by which the research is being prosecuted involve, firstly, the count of the total sockeye salmon in-go into Cultus lake, whether as adult spawning salmon, free-swimming fry, or eyed eggs, and secondly, a subsequent count of the resulting out-go from the lake, as sea-ward migrants. The

in-going count is transposed into the total number of eggs contained in all the female salmon which arrive at the counting weir. Only one method of propagation is practiced in each year and therefore the counts of migrating young are the actual results of the particular method tested.

In the following tables the actual returns have been reduced to indicate the results derived from each pair of spawning salmon. Each female sockeye contains, on the average, 4,500 eggs and accordingly, the data have been treated to represent the yield in sockeye migrants from each 4,500 lot of eggs.

Natural Propagation

In seasons of natural propagation the adult sockeye migrating to Cultus lake are arrested at a counting weir just below the lake. The total number of spawners is thus determined as well as the total number of eggs. The records for the natural spawning of the years 1925 and 1927 are:

Year of Operation	1925	1927
Total Number of eggs	17,473,500	250,060,500
Ratio of Sexes—0 : 0	2 : 5	1 : 2
Total sea-ward migrants	197,562	2,637,573
On basis of 4,500 eggs per pair of spawners :		
Total eggs deposited	4,500	4,500
Sea-ward Migrants	51	48
Per cent of total eggs	1.13	1.06

It will be observed that in natural propagation all losses from the egg to the down-stream migrant are lumped. There is, thus far, no means of dividing the losses into their component stages. *Nevertheless, slightly over one per cent of the total number of eggs capable of deposition on the spawning beds reached an age of one year and the sea-ward migrant stage.*

In spite of the fact that the deposition of eggs in 1927 was some fourteen times as great as in 1925 the end results vary only slightly. In other words, the capacity of the lake was not too severely taxed by the heavy spawning of 250,000,000 eggs.

One of the factors which complicates the determination of the success of natural propagation is the diverse ratio of numbers of males and females. It will be noted that in 1925 there were but two males for each five females. The effect of this inequality in numbers cannot even be surmised for as yet there is no more evidence that the sexes pair off evenly,

whereby the single females perish without achieving their purpose, than there is that one male may not serve satisfactorily two or more females. A predominance of males is most desirable and undoubtedly ensures a higher percentage of fertilization of eggs.

A shortage of males would seem to represent either one of Nature's weaknesses or a faulty system in the regulation of commercial fishing.

Artificial Propagation With Liberation of Fry

For artificial propagation the ascending fish are retained in an enclosed area of the creek until ready to spawn. Counts of the total numbers of adult sockeye are made up of the total number spawned and the total number that die in the enclosed area during the season. The individuals are spawned in the approved fashion as they become mature and the eggs are placed in the hatchery. Losses during development are accurately recorded and the total number of free-swimming fry liberated in Cultus lake thus established.

The results for the two seasons of artificial propagation with liberation of fry are:

Year of Operation	1926	1929
Total Number of Eggs	8,770,500	12,078,633
Ratio of Sexes, 0 : 0	5 : 3	1 : 2
Total sea-ward migrants	347,229	346,631
On basis of 4,500 eggs per pair of spawners:		
Total No. of Eggs	4,500	4,500
Eggs Collected and Placed in hatchery	3,330	3,479
Total Fry Liberated	3,036	2,777
Total Sea-ward Migrants	178	99+
Per cent of total Eggs	3.96	2.2+

The returns at migrating stage for fry liberation in the two years are far from alike and while there may be a small increase to the 99 yearling return for 1929 because of the addition of those individuals which remained in the lake for a second season and will migrate in the spring of 1932, the total for 1929 will certainly not reach that of 1926.

In any event *a substantial increase over natural propagation is evident, roughly 350 per cent,* which indicates that as far as the investigation has progressed, artificial propagation with fry liberation presents decided advantages over natural propagation.

Looking at the problem broadly, however, the end result of slightly under 4 per cent efficiency is woefully disappointing. The agencies contributing to this meagre return are quite obvious. In the first place it will be noted that a considerable loss occurred during spawning operations, both through fish dying unspawned—a total loss—and through incomplete stripping of eggs, a loss amounting in 1926 to 26 per cent and in 1929 to 36.8 per cent. Such a severe loss at this stage of operation may appear surprising, if not inconceivable, but it must be borne in mind that exceedingly stringent records are kept for this investigation, records that in themselves concede nothing to fate or misfortune. It is quite safe to say that were similar records taken at many of the salmon hatcheries of the Pacific coast which are pointed to with enthusiasm and acclaim as glittering examples of Man's prowess over Nature, many exuberant hearts would be broken.

Such close, inflexible records while perfectly justifiable under the circumstances must, in the final analysis, be temporized by a consideration of unusual conditions pertaining to the local situation, and for this reason the losses above mentioned may be somewhat discounted. To what extent cannot now be determined.

In the second place, the heaviest loss occurred subsequent to the liberation of the fry and took in the 1926 test a toll of 2,858 out of a total 3,036 fry or 94 per cent. Just what amount of this loss occurred immediately following liberation is undeterminable but in view of the fact that in the 1929 operations a fry scow was used to produce an automatic distribution of fry throughout the lake and that the fry escaped in excellent condition and yet, if anything, heavier losses took place, it might be postulated that mortality following liberation cannot be placed at the door of the process of liberation. For what amount of this slaughter predaceous enemy fish (Trout Dolly Varden, Squaw-fish) can be held responsible, the data do not disclose but it is felt that in large measure a plea of "Not Guilty" would be untenable. Steps are now being taken to obtain evidence on this point.

Artificial Propagation With Planting of Eyed Eggs

There is a school of fish culturists which maintains that a "Back to Nature" movement in artificial propagation is needed. In other words, these advocates postulate that if eyed salmon eggs are planted in the gravel beds of the stream, instead of fry being liberated, there are produced stronger,

healthier fry which are more self-reliant and intuitively better able to look after themselves. Other officials push the planting or liberating stage even further back and recommend the newly-fertilized egg for distribution purposes. There is no question but that eggs can be transported greater distances, in greater quantity and at less expense than fry and are therefore more suitable for restocking distant depleted or barren salmon areas; but the problem as to whether it is better to plant eggs in the gravel of the streams immediately upon arrival or rear them to the free-swimming fry stage in improvised hatcheries before liberating remains open to argument.

This method of planting eyed eggs at Cultus lake gave the following results:

Year of Operation	1928
Total Number of eggs	51,700,571
Ratio of sexes, o : o	1 : 3
On basis of 4,500 eggs per pair of spawners:	
Total eggs collected	2,844
Total eyed eggs for planting	2,612
Total sea-ward migrants	74
Per cent of total eggs	1.64

From the data obtained it would appear that the method of planting eyed eggs achieved an intermediate status between natural propagation and artificial propagation with liberation of fry. At this stage, however, it would seem unwise to make specific deductions. Owing to the comparatively great mass of eggs spawned and handled the losses in this period were somewhat abnormal also, according to expert opinion. The planting areas were not of the best. Confirmation of the results of this phase of the investigation are being obtained.

Pond Retention of Sockeye Salmon

Additional experiments were initiated to define the benefits derived from extended retention of sockeye salmon fry. The purpose of such retention was, to protect the young fry during their earlier stages and to release them only after they had reached a size when they were better enabled to cope with inimicable natural conditions.

Retaining ponds of the standard type used in the State of Washington, but entirely of wood were built. These ponds measured 60 ft. x 16 ft. x 3 ft., rounded ends, and a central partition as well as an inlet and outlet at same ends. Origin-

ally it was proposed that 500,000 sockeye fry should be retained, one-half to be liberated in the fall, the remaining half in the following spring. Unfortunately a disastrous infection developed about August 1, 1930 and, despite strenuous efforts to combat it, continued until fall. The total number of retained fry dwindled rapidly and by September 30, 1930 only a small fraction of the initial supply remained. A proportion of these were liberated, as planned, on October 6th, being marked at the time of liberation by the removal of the adipose fin. The remainder of the pond inhabitants were held during the winter and released on March 28, 1931, after being marked by the removal of the right pelvic fin.

At the time of the annual down-stream migration from Cultus lake in the spring of 1931, when the product of the artificial propagation with liberation of fry operations of 1929 was counted, strict watch for these two groups of marked individuals was kept and the numbers recorded. The results are given in comparison with the regular system of fry liberation:

Age when liberated	as Fry	At 5 Months	At 1 Year
Total Sockeye liberated	9,705,758	41,144	17,646
Total sockeye recovered as down-stream migrants	349,993	4,362	10,051
Per cent Survival	3.6	10.6	63.1
Length at time of down-stream migration	9.1 cm.	9.7 cm.	9.5 cm.

The success for the individuals retained for one year (63.1% of the total number liberated) is most striking. It is probably explained by the fact that the great majority of these individuals spent less than one month in the lake. Losses occurring during the winter were not heavy (9.8%) when one considers that many of the fish were recuperating from the ravages of the infection.

Returns from the five-month period of retention were a presentable advance over those for fish liberated as fry and might have been higher had the fingerlings been in perfect condition. Only the best fingerlings were chosen for liberation in the fall but some may have been included which were too weak to withstand the treatment connected with marking and liberation.

The results are highly illuminating but an endeavor to follow up the economic success of the experiment was vitiated by the infection. In any retention programme the cost of constructing and managing ponds and the expense of feeding must bulk largely in the determination of its economic value.

In conclusion it may be pointed out that while the results of the investigation into the comparative success of Natural and Artificial Propagation of Sockeye salmon have been given to date, the investigation is still proceeding and this paper may be considered, therefore, as a progress report. The data recorded are therefore by no means conclusive.

The research is being conducted along scientific lines, it is absolutely unbiased and impartial, and it forms a genuine effort to discover the fundamental merits and deficiencies of natural propagation and the accepted methods of artificial propagation to the end that the general attack on fishery problems may proceed and conservation measures be formulated on a sound basis.

Discussion

In the absence of Dr. Foerster, Mr. J. A. Rodd, gave a synopsis of the paper.

Mr. J. A. Rodd (Ottawa): Dr. Foerster's investigation, began in 1925, is planned to continue until 1936 so that it will cover a period of twelve years and will include three of the four-year cycles of the sockeye salmon in the Fraser river. The outlet of Cultus Lake is securely screened and every migrating fish, irrespective of age, is counted. Some years all the descending migrants are marked by the removal of one or more fins. The total in-go and the total out-go is ascertained each year.

In seasons of natural propagation, the adult migrating salmon are arrested at a counting weir just below the lake. They are detained there only long enough to be counted before they enter the lake for spawning. In seasons of artificial propagation the ascending fish are retained in the outlet creek below the lake until they are ready to spawn. The earlier fish are retained for several weeks under unnatural and, sometimes, crowded conditions, where they expend their energy in efforts to ascend, and are liable to bruise and injure themselves in fighting the fences.

At all other places in British Columbia, adult sockeye salmon are retained for propagation purposes above and not below a lake expansion in their "home" stream. Fish culturists, who are familiar with the habits and propagation of sockeye salmon, will, I believe, agree that long retention of unripe sockeye, particularly in the outlet of a lake, is not conducive to the best results from the standpoint of the death of the parent fish, the production of a large or normal yield of eggs and the production of eggs of the best quality.

In this investigation every female salmon which dies in the enclosures or below the fences is charged as a loss against artificial propagation

at the rate of 4,500 eggs for each female, irrespective of unfavorable conditions and the length of time the fish are retained. Considerable numbers of sockeye sometimes die under natural conditions in open waters before they spawn. Drs. Gilbert and Rich reported a heavy mortality amongst unspawned sockeye at Karluk river in 1926, and last year a somewhat similar condition was found in one of the tributaries of Babine Lake, British Columbia.

The return to date in descending migrants from natural propagation is a little better than one per cent of the number of eggs produced on the basis of 4,500 eggs for each female. The return from eyed eggs planted is a little better than the return from natural propagation, but is under two per cent, and the return from the distribution of free swimming fry is nearly four per cent. The return from the number of five months' old fingerlings distributed is 10.6 per cent and the return from yearlings is 63.1 per cent. The fingerling and yearling returns of 10.6 and 63.1 per cent respectively, do not include the loss that took place between the fry and fingerling stages and between the fry and yearling stages. These losses, as well as the cost of overhead feeding, etc., must be taken into consideration in the final analysis.

MR. WICKLIFF (Ohio): How deep is it necessary to cut the anal fin before regeneration?

MR. J. A. RODD: I could not tell you how deep Dr. Foerster cuts the fins, but he secures a goodly number of fish marked by him as yearlings when they return from the sea in their fourth year.

DR. C. HUBBS: I understand that it is necessary to cut clear down to the extreme base of the fin.

MR. WICKLIFF: Does that injure the fish?

DR. C. HUBBS: From the large number of returns obtained in some experiments in the Columbia river apparently it does not.

MR. WICKLIFF: How does that method compare with tagging?

MR. J. A. RODD: We have held experimental lots of marked fingerlings in troughs for from ten to twenty-one days without any loss. The removal of fins does not cause any immediate loss.

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After reviewing Dr. Foerster's important paper the Publication Committee requested Dr. Foerster to answer in the form of a discussion the following questions:

1. Were the conditions at the experimental rearing pond and hatchery ideal for rearing salmon?
2. What was the capacity and construction of the ponds?
3. Was the infection which depleted the stock identified?
4. Will you describe in detail the method of counting the marked outgoing salmon?
5. Will you explain the exact meaning of the word "pair" as used in your tables?

DR. R. E. FOERSTER: While we are unable to state definitely that the system of ponds used at Cultus Lake are ideal we are of the opinion that they are good. The water supply is plentiful, of good quality, although it does unfortunately, pass through a farm yard and might thus at any time be contaminated, and of low temperature. The temperature has never gone above 59 degrees Fahrenheit, even in the hottest summer day under full exposure to the sun. We believe that in these respects our water supply is satisfactory.

The ponds which are modified slightly from the standard oval ponds used in the State of Washington, are constructed of fir planking, with wooden bottoms, and are approximately 60 feet in length, 16 feet wide and three feet deep. About two and one-half feet of water is retained in the ponds and the inflow of water is roughly 100 gallons per minute.

The State of Washington Fisheries Department allows a capacity of 600,000 salmon fry per pond of this size but we have been content with 100,000 sockeye fry or fingerlings. This summer we tested out the ponds with Coho salmon and we had no trouble in holding 125,000 Coho salmon per pond.

Our pathologist discovered that the sockeye fingerlings during their disastrous period of mortality were heavily infected with *Costia necatrix.* He isolated specimens from sick and dead individuals but they were not abundant on living and normal specimens of sockeye. The symptoms of the disease were those of Costia infection but there was no response to the usual remedial treatments. We used copper sulphate, acetic acid and common salt, with practically no success. The infection was first observed when the fish exhibited a sluggish and indifferent disposition toward their food. Change of water current and of food had no effect and suddenly the losses increased tremendously. Despite every effort to combat the disease the mortality increased and continued for a period of some six weeks when it suddenly ceased. The remaining sockeye fingerlings while showing but slight growth during this period soon became active feeders again.

We were unable to assure ourselves that Costia was the causative agent of the epidemic. Temperature, usually guilty in such cases, was not abnormally high, and the water did not seem to be contaminated before entering the ponds. Our suspicions fell on the halibut meal which we were using as an alternate food with beef liver. It so happened that we commenced using a new supply of this meal just prior to the onset of the epidemic and we observed that the meal was of a darker color than the former supply. This phase of the problem is now being investigated from pathological and bio-chemical angles.

In connection with the main investigation we constructed at the outlet of Cultus lake a fine-mesh screen fence with a series of six traps at the down-stream end, the fence being on a slight angle to the stream flow. In these traps we coralled and counted the migrants passing from

the lake. After much experimentation, the best method was found to be simply the counting, one by one, of all fish in the traps. Each fish, whether there are 2,500,000 in the migration or 200,000, was handled separately. Where there are no marked fish to enumerate the handling was speeded up but in cases where the number of marked individuals was desired each fish was examined as it passed through the counter's hands. As a matter of fact, last spring when the data in question were obtained, all migrants from the lake were being marked by removal of both pelvics and the adipose fins before being released to proceed to sea. The separation of migrants already marked was therefore, quite easy, since the marker was bound to recognize at once a fish that had previously been marked because one fin which he had to remove was already missing. We endeavor, of course, to arrange experiments of this nature, where much observation or operation is involved, in years when we know the migration will not be too large.

I regret that by my use of the word "pair" I have made difficult a clear understanding of the complication which has arisen in the tests of natural propagation by the differing ratios from year to year of male and female sockeye. In the investigation we pay no attention to "pairs" of salmon. The whole investigation is based on the number of females and we calculate the deposition of eggs in natural spawning or the total possible collection in years of artificial propagation wholly on the basis of the number of females present at the counting weir. This is the only possible method in an investigation of this kind. In the tables of results obtained to date, I have used 4,500 eggs per pair of spawners, assuming only that this was the product of a pair of fish. Under the conditions which exist we cannot say that such is true. To simplify matters I would ask that you disregard the term "pair" in the tables and consider the 4,500 eggs as the product of a spawning female.

Where there is a super-abundance of female sockeye on the spawning beds there are no means at hand of estimating how many of the excess females are able to satisfactorily spawn their eggs. However, if the sexes were equal, we could be no more certain of the total deposition for we would be unable to ascertain whether all the females mated and spawned in the proper fashion or whether some strayed from the main spawning beds and drifted around unattended by a male. We base our calculations, therefore, as I have already said, on the total number of females present, and more or less disregard the males. The latter are counted in the usual way but we have no way of judging of their usefulness in the general spawning operation, except in artificial propagation where we can count directly the number of males used for spawning purposes.

PROPAGATION OF MINNOWS

LEWIS RADCLIFFE

Deputy Commissioner, U. S. Bureau of Fisheries

There is serious need for the development of a program of propagation of bait minnows. This need arises from a number of causes. For example, many of the states have issued stringent regulations respecting the seining of bait minnows in an effort to check the depletion of the natural stock. Many of these small fishes serve a very useful purpose in subsisting on microscopic animal and plant life (plankton) and on the vegetation in the water, converting such material into flesh food, suitable for consumption by predatory species, with which they do not compete for existence. The supply of predatory fishes, such as the basses, is governed to a large degree by the abundance of minnows in the water.

If these conclusions are accepted, it would appear important that we should not be satisfied with passive action such as the passage of prohibitions against the taking of minnows but should develop methods for increasing the stock of minnows in our streams by propagation and by the introduction of stocks of the best minnows in suitable waters. Having prohibited the taking of bait minnows, private enterprise should be encouraged to propagate suitable species for sale to the bait fisherman.

That all efforts in these fields be prosecuted intelligently, a biological study should be made of the habits of the most promising species so that we may evaluate the importance of each species, and, secondly, we should experimentally determine under controlled conditions the best methods of propagation to recommend to fish-culturists whether federal, state, or private agency. The development of such a program may prove that such action is necessary to yield the best results from our plantings of game fishes, i. e. we may not now be obtaining proper results because of an inadequate supply of food for the predatory species now placed in our waterways.

SPECIES

For the sake of being specific, it may be well to point out that the term "minnow" is applicable to the representatives of three families of fishes and that the adults are usually of small size. Many people loosely apply the term to any small fish encountered, including the young of species which grow to a larger size. Most of the minnows belong to the family

Cyprinidae which includes such well know forms as the roach or golden shiner (*Notemigonus*), the stone rollers (*Compostoma*), the dace or chub (*Semotilus*), the dace (*Leuciscus*), a large variety of species belonging to the genus *Notropis*, the goldfish (*Carassius*), the carp (*Cyprinus*), and others. Names such as dace, shiner, roach, chub, and minnow are more or less indiscriminately used with resultant confusion and complications.

The large family of killifishes (*Pœcillidæ*), including the top minnows (*Gambusia* and *Heterandria*), and a large number of species belonging to the genus *Fundulus*, as well as the mud minnows (family *Umbridæ*), are composed of small species which may be classed as minnows. Killifishes are found in fresh, brackish and salt water; the others are freshwater forms.

As would be expected, these fishes live under a large variety of conditions with individual preference and habits. Not only are there regional differences in distribution but recognizable differences with respect to the size and character of the bodies of water in which they occur, character of the bottom and the purity of waters preferred, rapidity of current, choice of haunts within a region and many other factors which need to be known before we can proceed intelligently in the propagation of individual species. Account should also be taken of the individual preferences of the predatory fishes for which they are intended to serve as food. It is also important to select species which are not unduly competitive for the same food supply with the predatory species. From this brief summary, the complexity of the problem will be evident. It should also be patent that the solution to these problems must be found, if fish culture is to make the progress expected of it.

Of the 24 species of Illinois minnows, whose habitat was classified by Forbes and Richardson (Fishes of Illinois), five species showed a marked preference for lowland lakes while upland lakes had a greater attraction for only one species, the majority of the species being resident of small rivers and creeks rather than the large rivers. Therefore it should be clear that most minnows will be undergoing a marked change in environment when they are removed to small stagnant ponds. Species like the chubs (*Semotilus*) spawn in running water, building their nests of gravel in fairly swift water. The blackhead minnow (*Pimephales promelas*), prefer still water and a muddy bottom and such species are apparently well suited to intensive cultivation in small ponds as indicated

by experiments at the U. S. Fisheries station at Fairport, Iowa.

The golden shiner also lends itself readily to intensive cultivation in small ponds. While such forms as the dace (*Leuciscus*), chubs (*Semotilus*) and shiners (*Hybognathus*), common to creeks and streams, may reproduce in small ponds under favorable conditions, careful experiments should be made to determine more definitely their adaptability to pond culture and their limitations.

The common goldfish has not proved particularly satisfactory, although it may prove of value, when reared in separate ponds and then fed to large fingerlings or to brood stock.

The use of the orange-spotted sunfish, (*Lepomis humilis*), has been recommended but because of its feeding habits, its value is questionable.

The larger species of minnows, such as the horned dace, which are predaceous, would not be expected to provide a large yield. Propagation efforts should center on species which are largely vegetable eaters, particularly those which prefer sluggish waters.

Propagation

In the cultivation of minnows, one should observe the general principles of pond culture. Only sufficient water to maintain the pond level is necessary. There should be a flourishing growth of aquatic vegetation but not sufficient to choke the pond. One engaging in this enterprise has the advantage in that he may use small pools and ponds scarcely adequate for the rearing of larger fish.

Fertilization—Fertilization of the pond margins may be very essential to produce vegetation in the abundance desired. For this purpose small quantities of such fertilizers as sheep manure, meat and fish scrap, superphosphate, soybean meal and the like may be used.

According to Davis and Wiebe (Experiments in the Culture of the Black Bass and other Pondfish): "The amount of fertilizer to be used will depend to a large extent on local conditions. If the pond soil is infertile, more fertilizer will be required than in ponds built in fertile soil. In our work with the 3 to 1 mixture of sheep manure and superphosphate, we have found that 550 pounds per acre for the entire season gave very satisfactory results. During one season we used from 670 to 742 pounds per acre. The results, however, were no better than when 550 pounds per acre were used. In the

small ponds as much as 936 pounds per acre were used. In one of these ponds 56 per cent of the bass put in as fry in June were removed as fingerlings in October. This is the highest percentage of survival that we have had at the Fairport station. Very good results have been obtained in the small-mouth black bass pond, when 472 pounds of a 3 to 2 mixture of sheep manure and superphosphate were used. It is possible, however, that the results would have been even better if more fertilizer had been used.

"Soybean meal has given good results when used at the rate of 575 to 700 pounds per acre during the season. Our maximum production of black bass fingerlings was obtained in a pond fertilized with soybean meal at the rate of 700 pounds per acre.

"In view of these results it is probable that in most cases from 500 to 1,000 pounds of fertilizer per acre of pond surface will be sufficient. However, if a pond is notably deficient in vegetation or if there is an exceptional amount of seepage, it will doubtless be necessary to use a considerably larger amount of fertilizer if the best results are to be obtained."

Daphnia—In the propagation of minnows, the use of daphnia as food supply for the minnows merits serious study. In this field, the work of Charles O. Hayford in rearing daphnia as food for young bass is of interest. He has produced daphnia in quantities sufficient to feed 200,000 two to four-inch bass; 600,000 one to two-inch bluegill sunfish, and 100,000 golden shiner fry. The daphnia may be found to be an excellent supplementary food for certain of the minnows. It is believed that forage fish will prove superior as a food for the young bass three to nine inches in length to the daphnia.

Forage Fish—The term "forage fish" is applied to those species of fish which are intended to serve as food for other fishes. It should be apparent that if we are to obtain a maximum production of bass and other game fish in restricted pond areas, we must provide as large an increase in food supply as is practicable. By feritlization as shown above, we greatly increase the production of microscopic life, including minute crustacea as well as the vegetation. This is the basic food supply of practically all young pondfish and for many fishes throughout their lives. Carnivorous fishes soon turn to insects and then to small fishes, feeding on the weaker members of their own kind or other small fishes which are present in abundance. While bass will continue to subsist on insects and crustacea during the first season, they prefer fish and will grow faster if an adequate fish diet is provided. Ulti-

mately it will be worth while to experiment with means for increasing the production of insects. In the meantime we should not fail to provide an abundance of forage fish, particularly species which feed on the plankton and vegetation and do not compete with the carnivorous species for food. It is also important that the forage fish have a late and prolonged spawning season. It is preferable that these species spawn after the spawning time of the game fish, so that the young will not be too large to be devoured by the young game fish and that they produce a number of broods during the season to maintain a supply of young fish for food for the growing game fishes. If the forage fish possess these characteristics, and are hardy and readily adaptable to pond conditions, they will serve to greatly augment the output of game fish.

Golden Shiner—The golden shiner (*Notemigonus crysoleucas*), is one of the best forage fish and bait minnows. The species is widely distributed from Canada to Florida, westward to the Mississippi drainage. It prefers slow streams and grassy ponds and occurs in lowland lakes, ponds and stagnant muddy ponds. It is an ideal pond fish and consumes a wide variety of foods. The young feed principally on minute crustacea and plankton algae, later feeding largely on algae or other vegetable material.

At the U. S. Fisheries station at Fairport, Iowa, in 1927, a pond .071 acres in area stocked with 36 adult shiners, yielded 17,700 young shiners which is equivalent to a production of about 250,000 per acre. In 1928, a pond of .073 acres in area stocked with 34 adults, yielded 2,339 fingerlings, equivalent to about 32,000 fish per acre. Some of the states such as Pennsylvania, have had notable success in propagating this species.

Blackhead Minnow—The blackhead or fathead minnow (*Pimephales promelas*), had also been used at the Fairport station as a forage fish with success. According to Davis and Wiebe—"The blackhead minnow is a small species with a wide geographical distribution, but is abundant only in certain localities. It is very adaptable to pond culture and will thrive in almost any type of pond if given a fair chance. It is a bottom feeder and is usually considered as belonging to the mud-eating group of minnows." According to Coyle (1930), the blackhead feeds largely on algae, the animal food being proportionately less abundant than that derived from plants. It apparently feeds quite indiscriminately on a large number of algae, and the writer concludes that 'The algal species found in the alimentary canal of the fathead depend upon the

habitat in which the fish is taken; yet the number and size of the gill rakers of the fish determine to a great extent what forms are retained in the alimentary canal.

"The blackhead has a long breeding season, spawning fish having been observed at Fairport from the middle of May to early August (Lord, 1927). The eggs are laid in masses on the underside of stones, boards, or other objects, and are closely guarded by the male. The young grow rapidly and mature in one year. This minnow is capable of producing a large number of fish in a limited area, as shown by the production in a small pond in 1928. Pond F 3, with an area of 0.073 acre, was stocked on May 9, with 295 adult blackheads. The pond was drained October 11 and produced 15,691 blackheads having a total weight of 26 pounds. This was at the rate of approximately 215,000 fish or 356 pounds per acre. No food other than fertilizer was added to the pond during the summer.

"It is evident that a minnow with such possibilities should make a good forage fish, but in our experiments with bass it has proved inferior to the golden shiner. This is probably due chiefly to the small size of the blackhead. Such small, soft fish fall an easy prey to the bass, and even the adults are devoured by the larger fingerlings before the summer is over. The result is that, even though the ponds may be heavily stocked with brood minnows in the spring, the blackheads are practically cleaned out before the ponds are drained in the fall, and the bass, deprived of their favorite food, begin to prey upon each other. There is some evidence that the blackhead may be a desirable forage fish for use with crappie, but we have not yet had an opportunity to try this combination on a sufficiently large scale to warrant definite conclusions.

"Since the blackhead is so prolific and feeds to such a large extent on plant material it will no doubt prove to be a valuable fish for growing in ponds by itself. As previously mentioned, the blackhead will thrive in almost any kind of a pond that is rich in vegetation, no matter how small it may be. Every pond station should have several ponds devoted solely to the propagation of forage minnows. Unless this is done there is always danger of losing one's stock of forage fish, since it not infrequently happens that practically every minnow in the bass ponds is devoured before fall. Furthermore, it is essential to have a supply of forage fish on hand for feeding to the brood stock. An occasional meal of minnows

will keep these fish in much better condition than if they are fed only artificial food."

Minnows For Stocking Natural Waters

In the selection of species to breed for stocking streams, most of the characteristics required of forage fish will apply except that a wider range of selection will be possible depending on the type of stream or lake to be stocked. Species which are hardy, prolific breeders which feed on vegetation and microscopic life and are not carnivorous are to be preferred. Consideration should also be given to the preferences of the game fish in waters to be stocked.

Bait Minnows

The first desideratum in the propagation of bait minnows is to select species for which there will be a ready sale to the anglers and are hardy, thus lessening the danger of heavy losses. In other respects, the requisites for forage fish apply.

In view of the tightening of regulations regarding the seining of minnows, creating a larger demand for live bait, the increased use of forage fish creating demands for brood stock for stocking ponds inhabited by game fish, the growing popularity of cooperative fish nurseries and the necessity of keeping natural streams adequately stocked not only with the game fish but with the items upon which they feed, there is urgent need for detailed information on the propagation of minnows. In the light of investigations made, it would appear that such work might be conducted on a commercial scale with profit to the operator. The foregoing has been written primarily for the purpose of focusing attention on the minnow question and the need for the development of an adequate policy with respect thereto.

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A FOLLOW-UP PROGRAM ON THE IMPOUNDED WATERS OF THE SACANDAGA RESERVOIR

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The trend has been in recent years to construct great, storage reservoirs for the purposes of general economic betterments. As time goes on, more and more streams will be dammed, creating suddenly artificial lakes of large dimensions. Potentially they are important in fish propagation and much interest attaches to them aside from their primary purposes of regulating streams for greater continuity of flow. The creating of these reservoirs is of such interest to the angler that in the same breath, as it were, in which these "new lakes" spring into existence there is a clamor from the Waltons for a full-fledged stocking policy.

The fact is we know little about how nature works on the sudden drowning of a valley, in what manner the biological and other factors operative in the newly created reservoir differ from the normal state of affairs in our natural lakes and ponds where the relation between animal and plant life is more nearly in balance. The creation, therefore, of any artificial reservoir in a community sets the problem of building up an understanding of the situation as regards fish life. Such a chance is now at hand in the completion of the new Sacandaga Reservoir—a regulatory project formed by damming one of the main branches of the Upper Hudson River.

Briefly, the description of the reservoir is this: The flooded basin is about the size of Lake George beautifully situated in the foothills of the Adirondacks about 60 miles north of Albany. The water surface at the high level comprises 26,700 acres or 41 square miles; and at low level, 35 square miles. It has an irregular shoreline of 125 miles. The depth when the reservoir is full is from 30 to 45 feet over a large part of the basin and a considerable area is permanently over 40 feet deep. The maximum depth near the dam is 70 feet.

The final stage of complete filling of the reservoir this past summer was marked by a preliminary survey to appraise its present condition, to secure a lead in the development of a stocking policy and to take bearings for future research. Scientists of the Conservation Department's Biological Survey, numbering twelve, who are experts in examining the

data of fishing waters spent a three-day period late in July for the purpose of initiating a constructive program of study which may be elaborated through a period of years.

During the spring and summer months, pike fishing in the reservoir has been the dominant sport, nearly every quarter of the lake yielding at some time during the season a satisfactory catch of this species of game fish. There is a general opinion that the reservoir has given an unusually good account of itself during the first year. This is in line with the general observation for newly impounded waters. In the analysis of the situation at Sacandaga, it would be surprising were it not so. In the basin which was flooded were several hundred acres of swamp land traversed by 20 miles or more of streams where in the accessible portions there had always been good pike fishing. In consequence of the flooding which covers the area for 30 feet or more the fishes scattered over the lake and waxed fat, following the release of countless checks operating from the standpoint of both food and enemies. One can visualize, for example, a number of "big ones" in the less accessible places that never were caught and the vast amount of food released gradually from the soil on flooding in the form of succulent worms, grubs and other animal life normally hidden away in the soil.

The catches of fish by the scientists* indicate a mixed population including trout and warm water species consistent with the character of the streams before submergence of the area. By net and seine catches 30 different species of fish were taken from the reservoir and the streams directly tributary to it. Among the game species taken in order of their abundance were pike, bullheads, perch and small-mouthed bass; carp were abundant, having been dispersed on the inundation of the swamp; rock bass, sunfish, chain pickerel and common suckers were taken; a speckled trout and a pike-perch were taken from the reservoir and a brown trout from one of the tributaries; the minnows and other species providing food for fish were abundant in number and excellent in variety and adaptable to the situation in both reservoir and tributary streams.

The chemist reports that for the current sampling period the reservoir is a warm water lake except where the depth exceeds 26 feet, the medium point, which registered a temperature of about 75 degrees Fahrenheit. At the bottom, at a depth of 52 feet, the temperature was 60 degrees Fahrenheit.

*The scientists who contributed toward the preliminary survey were: Dr. S. C. Bishop, Dr. P. R. Burkholder, Dr. H. M. Faigenbaum, C. W. Greene, Dr. G. W. Hunter, III, R. P. Hunter, W. J. Koster, R. A. Laubengayer, Bassett Maguire, T. T. Odell and Dr. C. K. Sibley.

The water is definitely acid and the gaseous relations indicate quite obviously the effect of decomposition of the flooded vegetation and the incident animal life. At the depth of 39 feet in the lower channel where the level will remain most constant, the readings of oxygen were zero. It was in this area that it was hoped lake trout might find a suitable habitat but the lack of oxygen seemingly precludes the stocking of this species.

The relationship of the vast amount of decaying vegetation of submerged swamp, meadow and pasture land to the development of a new aquatic flora and fauna form a central problem of great interest. The vegetation of the drowned valley still persists in various stages of decomposition, and one now comes upon the anomaly of potato or aster plants of some submerged former garden.

In the plant life of the reservoir will lie the basic source of the food supply of the future. At present none of the well known water weeds is represented. The microscopic life commonly called plankton which forms essential elements in the diet of all young fish and of several of older growth was sparsely represented.

The species of fish examined for parasites showed that infection was unusually low due, undoubtedly, as the parasitologist indicates, to the absence of snails and insect larvae not yet established in numbers in the lake to function to any extent as intermediate hosts for many of the worms that infect fish. Owing to the recent flooding of the basin many of the aquatic animals, including insects and other forms which enter into the dietary of fishes, were absent, having not yet become established in numbers to be conspicuous in dredge samples or to be found in the stomach contents of fishes. It is important to note that a small pond, which is an auxiliary of the reservoir overflowing into it over a dam, serves apparently as a nursery for food organisms with a stock supply of snails, midges, etc.

So far as the question of stocking the reservoir is concerned, it must be considered a vast, experimental laboratory for a period of years. The reservoir itself is at once the salient feature in the situation, though it seemingly strikes a cleavage between the devotee of stream fishing and of lake fishing. Nearly all the streams entering the reservoir are trout streams with natural barriers, few or non-existent. One of the tributary streams, the West Branch, is a notably fine trout water. At present no barrier exists to stop a run of the predacious species up this stream. How sharply the barrier of temperature and other conditions incident to annual

changes of level in the reservoir may distinguish the habitats of the trout and pike, for example, is problematical at this stage.

The large number of predacious species already in the reservoir, pike, small-mouthed bass, perch, bullheads, rock bass and sunfish, argues against the introduction of more fish-eating species like large-mouthed bass, e. g., which has been urged. However, this species and the pike-perch may be encouraged if conditions warrant their introduction. All are consumers of minnows whose basic food supply is not yet in good balance. It would seem also that the idea of planting lake trout which has been proposed is definitely disposed of for however one looks at this question, from the standpoint of the oxygen supply, the temperature or the number of competing predators, there is no escape from the conclusion that plantings of this species would be wasted.

One may conclude with a note of warning. Large catches of fish undoubtedly count heavily in the early stages of reservoir history. Therefore, reasonable caution should be exercised against overzealous fishing and additional protection granted if conditions warrant it.

This ends the first chronicle of a proposed continuation study of the Sacandaga Reservoir.

Discussion

DR. MOORE: By way of contrast I should like to say just a word about your local large reservoir here which I saw when I went out to Lake Hamilton yesterday. It is apparently a reservoir of about the same area as the one I have described, but its fluctuations are relatively small, compared with the fluctuations in the Sacandaga. The spread of water over the area in the basin is more nearly confined to your river bed than is the case of the Sacandaga, whose shape is something like a gigantic bagpipe, the bag part being subject to seasonal fluctuations, also your local reservoir is situated in a warm climate where the food question is apparently less difficult; that is, the food supply carries through more months of the year than in New York state. I should say, therefore, that from the standpoint of propagation it is a most important project.

MR. RODD (Ottawa): As far as your studies have gone, have you any idea when the fermentation of the bottom organisms would reach a state of natural balance or become neutralized?

DR. MOORE: Not at present. With the drowning of pasture land or swamp and the margins of the river bed, considerable fermentation has gone on, but the plants are all there. You can find golden rod, dwarf willows and the green shoots of cat-tails. It will take a long time before the decomposition has progressed to anything like a state of balance.

SODIUM ARSENITE FOR CONTROLLING SUBMERGED VEGETATION IN FISH PONDS

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A. GENERAL CONSIDERATION

The control of submerged vegetation is an acute problem in a fish pond which can not be drained. The sloughs which we are using as fish ponds in the Upper Mississippi Wild Life and Fish Refuge can not be drained, consequently we have been in "hand to hand" combat with weeds during the past three summers. We have, at the present time, assurance that we can keep the upper hand in the weed situation in our ponds.

The problem in using this chemical is one of maintenance of a sufficient supply of food to obtain the normal percentage of survival and growth of young fish. We know that we can destroy the vegetation in ponds where it is dense without killing the young fish. Sodium arsenite has a decided advantage over copper sulphate in this respect. It is well known, for example, that three parts per million of copper sulphate will destroy young fish directly of its own toxicity while we have used four and five parts per million of arsenious oxide (As_2O_3) equivalent in the sodium arsenite solution without mortality. Wiebe (1930, p. 276), reports the use of as much as seven p.p.m. of arsenious oxide on several of our common warm water fishes retained in aquaria without evident ill effects.

One of the main objectives of our experiments during the summer of 1929 was to determine the concentration of sodium arsenite that could be used in ponds in which the vegetation was becoming excessively abundant and still maintain plankton and bottom organisms in sufficient numbers to support the fish in them. The value arrived at was 1.7-2.0 parts per million of arsenious oxide equivalent in the sodium arsenite solution[1]. The details of these experiments will be published soon, and for this reason will not be described at this time.

During the past winter, Mr. O. L. Meehean, U. S. Bureau

(1) On June 16, and 17, 1931, the average total hardness in eleven ponds was 101.1 parts per million, ranging from 30-165 p.p.m. The methyl orange alkalinity averaged 110.5 p.p.m. and ranged from 58.7-170 p.p.m. The Mississippi River stage at this time was .9 and 1.1 feet, respectively, above low water mark on the river gage at Winona, Minn.

Water of this average hardness and alkalinity is called moderately hard and moderately alkaline, but is near the lower limit of each connotation. Water from 51-100 p.p.m. is called relatively soft water.

of Fisheries, and I performed a series of direct experiments in aquaria at the U. S. Biological Station at Fairport, Iowa, on effects of different concentrations of sodium arsenite on different kinds of bottom and weed-dwelling organisms, entomostraca, protozoa, and algae. The result of this study have not yet been published, but they were very encouraging. In general, concentration exceeding 2.5 p.p.m. of arsenious oxide were required to kill such important organisms as midge fly larvae; mayfly, damselfly, and dragonfly nymphs; fresh-water Amphipods, and Isopods. As much as 95.9 per cent of survival was attained by dragonfly nymphs of the species *Libellula saturata* and *L. puchella* exposed for five days to 14 p.p.m. of As_2O_3 equivalent.

We are reminded, however, that the animals which most of our warm water game and food fishes feed upon, are ultimately dependent on plants for food. Unless plants, algae or submerged aquatics, are maintained, the animal food will eventually disappear. Theoretically, a pond without the larger aquatic plants, but with algae and large numbers of water fleas, would be ideal in which to plant, grow, and handle young fish. I could give one example of a pond of this type which was a good producer, but several times as many examples of those which were not.

Our experiments and experience has shown that it is a good policy not to treat our ponds after an excessive growth has developed. The best time to treat them appears to be late in April or early in May. By this time many of the embryo plants have emerged from their seeds and begun growing upward. Treating early has several advantages among which are the following: (1) smaller concentrations of the sodium arsenite solution (1.7-2.0 p.p.m.) can be used. This, in turn, reduces costs. (2) Other seeds or fruiting bodies developing later produce plants which may be allowed to grow unhampered and furnish an adequate supply for organisms that require vegetation for food, reproduction, or protection. A mass of vegetation, if killed, will sink to the bottom and decompose. In the decomposition process, oxygen is used, and if the mass of vegetation is great, the oxygen in the pond may become entirely exhausted.

We learned during the past spring that the scarcity of vegetation early in the season in several of our ponds is no indication of the quantity of vegetation which may develop later. Our practice will be to treat our ponds early whether we expect a good growth of vegetation or not. Exceptions will be

made in ponds which are not normally heavy vegetation producers.

B. Nature of The Chemical And Quantities Used in The Treatments

The sodium arsenite solution is the commercial "Sodium Arsenite Weed Killer, Four Pound Material", a product of the U. S. S. Lead Refinery Inc., East Chicago, Indiana. It is a heavy solution, brown in color and almost syrup-like in consistency. The commercial product is sold in five, ten and fifty gallon non-returnable metal containers.

Most of the arsenic in "Sodium Arsenite Weed Killer" exists in the form of sodium metaarsenite ($NaAsO_2$) with probable small amounts as Na_3AsO_3 and Na_2HAsO_3. The commercial four pound weed killer contains four pounds of arsenious oxide (As_2O_3) per gallon. One gallon of this material weighs 12.63 pounds. Therefore the As_2O_3 is equivalent to 31.8 per cent of the total weight. Parts per million of this solution are calculated in relation to gallons of weed killer to numbers of cubic feet of water to be treated. One gallon of weed killer to 4,000,000 pounds of water would equal one part of As_2O_3 by weight, to 1,000,000 parts of water. 4,000,000 divided by 62.42 (weight of one cubic foot of water) equals 64,082 cubic feet. Therefore, when one gallon of weed killer is added to 64,082 cubic feet of water, the mixture contains one part As_2O_3 per million parts of water.

It has already been stated that concentrations greater than about 1.7-2.0 parts per million probably can not be used, if it is desired to maintain a supply of microscopic plant and animal food in our slough water.

If vegetation is becoming excessive early in the season, it would undoubtedly be better to treat two or three times with about 1.7-2.0 p.p.m. at two or three week intervals than to use higher concentrations and risk destruction of a considerable part of the natural food supply.

Where feeding is done artificially, concentrations double those already mentioned could be used without danger to our common warm water game fishes. (To my knowledge, trout have not yet been experimented with).

The amount of sodium arsenite which will be required to bring vegetation under control will depend upon such factors as (1) hardness of the water, (2) kinds of vegetation to be destroyed, (3) amount of vegetation present, (4) water temperature.

With regard to the first factor of hardness, our sloughs average about 101.1 p.p.m. of total hardness and 110.5 p.p.m. of alkalinity. With increasing hardness more chemical will undoubtedly be required, and the rate at which the arsenic disappears from the water will be increased.

We have observed that a concentration of from 1.7-2.0 p.p.m. has been sufficient to destroy most of the varieties of submerged aquatic plants that we have in our sloughs. Our most common plants are *Ceratophyllum demersum, Potamogeton interior, P. filiformis, Heteranthera dubia, P. pectinatus, P. foliosus, P. compressus, P. americanus,* and *Elodea occidentalis* (?). The latter species appears to be hardiest of all, but fortunately it has not caused us a great deal of trouble thus far. The preceding species respond well to the treatments.

Ceratophyllum demersum is our dominant plant, or was originally. It does not have true roots and can thrive floating about free in the water, though it is often found attached to the bottom. Within three or four days after a treatment, it losses its power to produce oxygen in the presence of light and sinks to the bottom. The leaves become detached from the stems and drift about on the surface of the pond until washed ashore or sink to the bottom where they decay. The other rooted plants collapse and disintegrate in place.

Where vegetation is very dense, the amount of sodium arsenite solution required is increased. Just how much more chemical is required per unit weight of vegetation has not yet been determined.

Since ions travel more rapidly in warm water, and physiological processes are accelerated by rising temperature, it seems natural to conclude that quicker and more uniform results can be obtained when the water is warm.

C. Method of Treating Ponds

All ponds which have been treated with sodium arsenite have first been measured carefully in the following manner: A telescope and rod, graduated in feet and tenths of a foot, were used in securing measurements of lengths and widths of sections. The ponds have been divided into sections in order to obtain greater uniformity in spraying. Depths were recorded by sounding at frequent and regular intervals across the pond. In the wider ponds, a rope with cork floats spaced ten feet apart was used, and soundings were made at each cork. The average width and depth of an irregularly shaped

pond must be obtained by measuring across at regular intervals through the length of the pond.

In spraying, the chemical, after being diluted about one half with the pond water, is distributed as evenly as possible over the surface, due consideration being given to the depths of water in different parts of the pond. Treatments were made on the basis of total volume of water in each section.

A three gallon Hudson Sprayer has been adapted to our work, although any pressure sprayer could be used which will throw a wide stream of spray. Instead of the regular single nozzle and delivery tube, we have used a copper tube eight feet long equipped with four nozzles equi-distant apart. This tube is supported by a rack which extends about three feet beyond the back end of our dinghy boat. All nozzles are controlled by a single lever as in the regular Hudson Sprayers, manufactured by the Hudson Manufacturing Co., Minneapolis, Minn.

The spraying tank and entire apparatus should be thoroughly washed after using. The use of rubber gloves while handling the chemical is recommended especially when one has open cuts or wounds. Sodium thiosuphate, photographers' "Hypo" is an antidote. This chemical will remove any paint or varnish on contact in the undiluted state.

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Discussion

MR. TITCOMB: Is the water soft in the ponds which you carried out these experiments?

MR. EUGENE SURBER: It is moderately hard water.

MR. TITCOMB: Did you have to thin out the syrup before using it in the sprayer?

MR. EUGENE SURBER: We usually dilute it one-half to one-third—say about one-third of the sodium arsenite solution to two-thirds pond water, taken directly from the pond.

MR. TITCOMB: As I gather, you could take a section of say a quarter of an acre and spray that, leaving the surrounding area unsprayed. Would you indicate the results on that quarter of an acre?

MR. EUGENE SURBER: During the summer of 1929 we started our experiments on a pond which we had divided across the middle with a screen. We killed the vegetation in the upper end of the pond and the vegetation continued to grow just as normally as ever in the lower

section; so that one-half of the pond might be sprayed, leaving the other half, to obtain the desired results, provided the pond is large enough. I do not imagine it could be done in an acre pond—this was a three acre pond; and of course you would have a gradual diffusion of the chemical from that upper section into the lower section. That would be expected, because if a chemical is in solution the ions will travel in all directions.

MR. TITCOMB: I have in mind areas where people want a bathing place in a pond of say ten or twenty acres. Would it be possible to spray an acre, say, around one edge, with satisfactory results, without the effects of the solution extending very far out?

MR. EUGENE SURBER: It would depend upon the lake, its contour, whether there was much open water, or just how much wind action the lake had. In a lake with a good deal of wind action of course you would have currents set up that would probably carry the solution out and distribute it through the lake and not do the particular section treated a great deal of good. I have not had any experience with very large bodies of water; probably four acres has been the largest sized pond I have tried to deal with.

MR. TITCOMB: If you could do that in a time of still water you probably could produce a very beneficial effect on the area around the shore without affecting the whole pond?

MR. EUGENE SURBER: I imagine so.

MR. TITCOMB: This is a very interesting and valuable addition to what we have already had on this subject.

MR. LANGLOIS (Ohio): Mr. Titcomb may be interested in an experience we had with sodium arsenite in Ohio. We had a five gallon tank sprayer, and as we had no boat on our hatchery pond Mr. Wickliff and I just worked around the shore, and with our comparatively short reach we managed to cover an area of perhaps eight or ten feet from the shore. The bulk of the pond was covered with this emergent vegetation, and the vegetation was affected only in the area all around the shore where we worked. In that area after about six days the leaves turned brown, curled up and presently sunk to the bottom, but the bulk of the vegetation in the middle of the pond was not affected.

MR. TITCOMB: Isn't that a rather valuable contribution to our knowledge? If we can clear around the shore without affecting the rest of the vegetation, can we not use that in our pond culture activities?

MR. LANGLOIS: I think so.

DR. HUBBS: I would like to have explained to us—the question occurs to me as I know it does to some of the others in the audience—the exact situations in which this arsenite treatment would be recommended. We understand, of course, that in a heavily fertilized fingerling pond it is necessary to control the weeds in one way or another.

In Michigan and probably in other northern states the idea is occurring to us to carry out a plan for the fertilization of our lakes in order to increase their natural productivity; if we do that, is it going to be desirable to try this arsenite treatment in the lakes? It brings up the question as to the role the major aquatic vegetation really plays.

Our limnologist at Michigan, Professor Welsh, is very much impressed with the importance of these major weeds in the economy of the lakes. A great many of the arthropods feed directly upon the major aquatic vegetation itself. We all know the smaller food organisms on the vegetation; practically every little stem has a large number of organisms up the side of it; in a good many lakes every little leaf is bored through with organisms feeding upon that plant material. There is a great plankton production, of course, immediately above the vegetation in many of our lakes.

I was just wondering how far this treatment could be applied. I am not questioning its value in certain special cases. And there is another question, if it could be answered at the same time: Mr. Westerman has just mentioned here that in some of the ponds under his charge in Michigan he has found that the introduction of a considerable number of crayfish into the ponds is sufficient to keep down the growth of the weeds. Possibly we can have some explanation of the extent to which this treatment can positively be applied and the possibility of biological rather than chemical control of excessive plant growth.

President LeCompte: We have a paper by Dr. Wiebe which also deals with this problem, and that will be presented next.

THE ARSENIC CONTENT OF LARGE-MOUTH BLACK BASS (*MICROPTERUS SALMOIDES LACEPEDE*) FINGERLINGS

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Introduction

At the Toronto meeting of this society one of us (Wiebe 1930) read a paper in which it was shown that 5 species of game fish and 3 species of forage fish were not injured by the addition to the water of quantities of arsenic considerably in excess of those required for the destruction of vegetation. The question that was not considered in that paper, was that of a possible storage of arsenic by the fish. This second paper on arsenic deals with the results of an investigation undertaken for the purpose of determining if these fish, as a result of exposure to the arsenic treatment, will accumulate sufficient arsenic to make them unfit for human consumption. For practical reasons the work has been confined to one species of fish. It may perhaps be assumed that our different species of pond fish do not vary a great deal in their arsenic metabolism.

The experimental and the analytical work were carried out at the U. S. Fisheries Laboratory at Fairport and at the Department of Pharmacology of the University of Iowa, respectively.

Results for arsenic are expressed in terms of As_2O_3. Weights throughout this paper are the wet weight of the tissue. The entire fish were used for the analysis.

Data

(1) Domestic Controls

The first lot of fish analyzed were 6 bass fingerlings that had been reared at Fairporrt during the summer of 1930 and which had not been exposed to any As_2O_3 treatment. All the

analysis on these fish gave negative results; even the qualitative Marsh test proved negative. Known quantities of arsenic added to these tissue were well recovered which showed that the method was not at fault. This work was repeated with 4 additional fish of the same category. These too gave negative results in all cases.

(2) Domestic Treated

The next lot of fish consisted of 5 domestic bass that had been exposed to the following treatments: On June 1 enough As_2O_3 was added to the water to make a concentration of 4 p.p.m., of As_2O_3. This treatment was repeated on June 9 without change of water. On the 17th they were transferred to untreated water and on the 29th they were analyzed for arsenic. The results are shown in Table 1. The results show that these fish accumulated appreciable quantities of arsenic. The amount ranges from 0.411 mgs., to 0.965 mg., per kilogram of fish. The average for 5 fish being 0.703 mg. per Kg.

TABLE 1

No.	Wt. of fish in grams	As_2O_3 recovered in milligrams	Milligrams of As_2O_3 per kilogram
1	14.5	0.014	0.965
2	29.0	0.018	0.620
3	31.0	0.018	0.580
4	17.0	0.016	0.941
5	34.0	0.014	0.411
Average			0.703

(3) Rock River Controls

The next lot of fish analyzed consisted of 9 bass from the Rock River in Illinois. These fish were not subjected to any arsenic treatment. The results of these analysis are shown in Table 2.

TABLE 2

No.	Wt. of fish in grams	As_2O_3 recovered in milligrams	Milligrams of As_2O_3 per kilogram
1	14.0	0.0015	0.107
2	10.0	0.001	0.100
3	14.0	0.0225	1.60
4	17.0	0.002	0.117
5	34.0	0.0135	0.397
6	31.0	0.011	0.354
7	36.0	0.011	0.305
8	37.0	0.020	0.425
9	66.0	0.007	0.106
Average			0.390

Table 2 shows that these untreated fish from the Rock River contained appreciable quantities of arsenic ranging from 0.100 mg., per Kg., to 1.60 mg., per Kg. Average for 9 determinations equals 0.390. Only 4 out of 9 showed arsenic values appreciably below those obtained from the treated fish in Table 2. Four fish gave values comparable to those shown in Table 2, while fish number 3 gave a value far in excess of any value obtained on the exposed domestic fish. This high value for No. 3 of this lot is, in fact, higher than any value obtained on any of the fish examined.

(4) Rock River Fish Treated

This lot consisted of 5 fish taken from the Rock River at the same time that those of lot 3 were taken. These fish were placed in an aquarium and enough As_2O_3 added to make a concentration of 8 p.p.m. They were left in this water from July 18 to 24 when they were analyzed for arsenic. The results are shown in Table 3. The results show that the average amount of arsenic in these exposed fish is slightly better than twice the value obtained for the controls. However, the high value in Table 3 is still considerably below the minimum value shown in Table 2.

TABLE 3

No.	Wt. of fish in grams	As_2O_3 recovered in milligrams	Milligrams of As_2O_3 per kilogram
1	27	0.0375	1.38
2	24	0.030	1.25
3	60	0.040	0.660
4	19	0.004	0.210
5	15	0.014	0.930
Average			0.886

(5) Mississippi River Control

In order to get a comparison of the arsenic content of the fish from the Rock River and from the Mississippi River a lot consisting of 6 fish from the Mississippi River were analyzed. The results are tabulated in Table 4. The results show that these fish contain appreciable amounts of arsenic, although values obtained are much lower than those obtained from the Rock River controls. The minimum value for the Mississippi River fish is, however, only slightly below the minimum value for the Rock River fish.

TABLE 4

No.	Wt. of fish in grams	As_2O_3 recovered in milligrams	Milligrams of As_2O_3 per kilogram
1	28.0	0.0035	0.125
2	160.0	0.025	0.156
3	112.0	0.012	0.107
4	137.0	0.009	0.0656
5	100.0	0.009	0.090
Average			0.108

(6) Rock River And Mississippi River Fish Fed Known Amounts of Arsenic in The Form of As_2O_3.

An attempt to feed bass known amounts of As_2O_3 met with very little success. First we tried to administer the arsenic by mixing definite amounts of As_2O_3 in solution with an artificial food composed of shrimp bran and fish meal in equal proportion. This treated food was fed to both domestic and to Rock River fish. These fish had been educated to take this food without the arsenic. When they were given the arsenic treated mixture, they soon quit taking it, and what they had taken they regurgitated. This mode of procedure was therefore abandoned.

The next method tried was no inject definite amounts of As_2O_3 into the body cavity of minnows. The bass took these minnows very readily, and it seemed that an ideal feeding method had been discovered. Pretty soon, however, these minnows too were regurgitated. Sometimes these minnows were thrown up within 5 minutes and generally within 30 minutes, but in a few instances several hours elapesd before regurgitation occurred. Out of 45 trials 2 were successful and the data for these 2 bass are given in Table 5. Both of these fish happened to be from the Rock River.

The reason why a larger number of bass did not retain the injected minnows is thought to be as follows: As the muscles of the stomach contract they exert a certain amount of pressure on the minnow. This pressure would tend to squeeze out some of the As_2O_3 solution from the body cavity of the minnow, and apparently the arsenic acts as an emetic.

The values shown in Table 5 are low as compared with the values for Tables 1, and 3, for instance.

TABLE 5

No.	Date As_2O_3 fed in mg.	Amount As_2O_3 fed in mg.	Date fish were analyzed	Wt. of fish	No.	Amt. of As_2O_3 recovered in mg.	Amt. of As_2O_3 per Kg. of fish
1	7/22/31	3 mg.	7/31/31	43.2	1	0.019	0.439
2	7/22/31	2 mg.	7/31/31	37.6	2	0.0095	0.252

(7) Rock River Bass Treated

These fish are of the same original stock as those mentioned in 3, 4, and 5. They were placed in an aquarium on July 23. To the water in the aquarium enough As_2O_3 solution was added to make a concentration 3 p.p.m., of As_2O_3. Without changing the water this arsenic treatment was repeated on July 29, August 10, 21, and 31. The fish were left in the water until September 3 when part of them were analyzed for arsenic and the balance transferred to untreated water. These latter fish were analyzed on September 10. The results for the fish analyzed on the 3rd of September and September 10 are shown in Table 6.

TABLE 6

No.	Wt. of fish	Mg. of As_2O_3 recovered	Mg. of As_2O_3 per Kg. of fish
1	15	0.013	0.866
2	17	0.021	1.23
3	15	0.015	1.00
4	25	0.016	0.640
5	21	0.0055	0.261 (?) (Doubtful value. Probably low)
Average for fish analyzed September 3			0.799
1	15	0.005	0.333
2	19	0.0055	0.289
3	22	0.017	0.772
4	12.5	0.010	0.800
5	13.0	0.007	0.538
Average for fish analyzed September 10			0.546

While these bass were in the arsenic treated water, they were fed on minnows that were kept in arsenic treated water and were fed food soaked in dilute solution of As_2O_3. Plankton was also put into the trough that contained the minnows. The object of this feeding experiment was to determine just how much arsenic it would be possible to accumulate in these bass. From the nature of the thing it was of course impossible to tell how much arsenic each bass took. It was thought, however, that this would simulate conditions in a bass pond where the arsenic treatment was used.

Table 6 shows that these fish contained less arsenic than those mentioned in section 4. It is also interesting to note that the fish analyzed on the 10th contain less arsenic than the ones analyzed on the 3rd. This suggests the elimination of arsenic.

(8) Domestic Fish Treated

These domestic fish were treated in the same manner as the Rock River fish in the section just preceding. The only difference being that the arsenic treatment was begun on July 29 instead of on the 23rd, and that the water was treated 4 times making a total of 12 p.p.m. of As_2O_3 added as compared with a total of 15 p.p.m. added to the aquarium containing the Rock River fish. These domestic fish were all analyzed on September 3. The results are shown in Table 7. Although these fish were exposed to more arsenic than the domestic fish mentioned in section 3, they contained considerably less arsenic.

TABLE 7

No.	Wt. of fish	Mg. of As_2O_3 recovered	Mg. of As_2O_3 per Kg. of fish
1	26	0.022	0.846
2	21	0.026	0.123
3	15	0.019	0.126
4	19	0.011	0.578
5	28	0.017	0.607
Average			0.456

(9) Trempealeau Fish

Table 8 shows the results of analysis of some bass taken from a slough near Trempealeau, Wisconsin. This slough had been treated with sodium arsenite as follows: On June 15 the entire slough was treated with 1.7 p.p.m. On August

15 about one-third of the slough area was treated with 3 p.p.m. On August 21 the entire pond was treated with 3 p.p.m. of sodium arsenite. The samples of bass were taken from the slough on Aug. 25th and were analyzed for arsenic on Sept. 10th.

TABLE 8

No.	Wt. of fish	Mg. of As_2O_3 recovered	Mg. of As_2O_3 per Kg. of fish
1 (3 fish)	23	0.011	0.478
2 (2 fish)	18	0.0055	0.305
3 (2 fish)	21	0.0045	0.214
4 (1 fish)	100	0.031	0.310
Average			0.326

This treatment destroyed the vegetation without destroying the fish. Table 8 shows that the average arsenic content of this lot of fish is lower than the average for any lot of fish except the Mississippi River and the domestic controls.

The Trempealeau fish and the data on slough treatment were supplied by Mr. E. W. Surber. Mr. Surber's cooperation is greatly appreciated.

Discussion

One thing that seems quite apparent is that freshwater fish taken from natural waters contain appreciable quantities of arsenic. In fact some wild fish seem to contain more arsenic than some other fish seem to acquire when exposed to the arsenic treatment.

Another thing that appears certain is that the amount of arsenic in fish is subject to great variation. This appears to be the case under natural as well as under experimental conditions. The arsenic content of control fish from the Rock River which were all taken at the same time and place ranged from 0.100 mg. per Kg. to 1.60 mg. per Kg. Domestic fish exposed to essentially the same treatment showed a variation in the arsenic content ranging from 0.411 mg. per Kg. to 0.965 mg. per Kg.

It also appears that fish acquire just so much arsenic, and after that, they acquire no more even if the treatment is continued. The Rock River fish that were treated with 8 p.p.m., for instance, contained more arsenic than those exposed to a total of 15 p.p.m.

Before considering the question of whether fish containing the quantities of arsenic reported in this paper are safe for

human consumption, it might be well to call your attention to a few interesting observations made by other people that have been interested in the matter of arsenic poisoning.

According to Sodolin (1928) in addition to a few vegetables, fish are the only ordinary food stuffs that contain appreciable quantities of arsenic.

Although according to Blumendahl (1908) there is no such thing as physiological arsenic in the higher animals, that is no arsenic occurs as a true constituent of body tissue, the occurrence of arsenic in the urin of normal human beings is not uncommon. (The menstrual blood of normal woman contains 0.28 mg. of arsenic per Kg. of blood). This arsenic is all derived from the food and drink, principally from fish and beer. In England a few years ago many people were poisoned, some fatally, by arsenic contained in their beer.

Marine fish probably contain more arsenic than freshwater fish. The Swedish Arsenic Commission found that the arsenic content of the Dorsch (Cod) ranged from 0.5 mg. to 4.1 mg. per Kg. (Average 1.3 mg.). These results are high as compared with our results obtained from the analysis of bass. According to Sodolin the amount of arsenic present in the tissue of a fish depends (1) on the amount of arsenic in the food of the fish and (2) on the amount of fat in the fish. The first factor accounts for the greater amount of arsenic in marine fish because the water of the ocean contains appreciable quantities of arsenite. Appreciable amounts of this arsenic appear in the marine algae which are the basic food supply.

Sodolin has shown that the arsenic is more abundant in the liver of the Dorsch than in the muscle. He obtained the following value from the analysis of 2 Dorsche.

Fish No. 1—Liver contained 0.7 mg. of arsenic per Kg.
Muscle contained 0.4 mg. of arsenic per Kg.

Fish No. 2—Liver contained 3.2 mg. of arsenic per Kg.
Muscle contained 0.8 mg. of arsenic per Kg.

He claims that the arsenic occurs in the Lebertran or fatty tissue of the liver. From this he concludes: that if two fish, one having a high fat content and the other a low fat content, fed on food containing the same amount of arsenic, the fat fish would have the higher arsenic content.

In our work because we used smaller fish, it has not been possible to determine the distribution of the arsenic in the fish. (It is hoped that we may do so this next winter). On

the basis of Sodolin's observation we may assume that our pond fish—bass, crappie, and bluegill—would not vary much in their arsenic metabolism. None of these species have a high fat content.

It is a well known fact that in the case of arsenic poisoning Sodolin loc. cit., the maximum quantities of arsenic occur in the liver.

Blumendahl reports a case where 10.5 mg. of arsenic were administered to a woman during a six day interval. On the last days of this treatment 3 mg., of arsenic were administered. This amount of arsenic produced no ill effects.

I think we are now ready to consider whether or not the sodium arsenite treatment as used in our fish ponds makes these exposed fish unfit for human consumption. Since the hatchery is not directly interested in the fish after the fingerling stage or after they have been planted, we may confine our discussion to a consideration of whether the amount of arsenic that is in the exposed fish when they are planted is enough to make them unfit for human consumption when they attain legal size. (We are assuming that all this arsenic is retained until these fish reach legal size).

TABLE 9

Lot	No. of fish		Mgs. of As_2O_3 per kg.
Domestic controls	10		0
Domestic As_2O_3 added to water	5		0.703
Domestic As_2O_3 added to water + arsenic treated food	5		0.456
Rock River control	9		0.390
Rock River As_2O_3 added to water	5		0.886
Rock River As_2O_3 +arsenic treated food	5	(Sept. 3	0.799
Rock River As_2O_3 +arsenic treated food		(Sept. 10	?
Mississippi River control	5		0.108
Trempealeau	8		0.326

In Table 9 we have a summary of the average amount of arsenic found in each lot of bass fingerlings examined. Leaving out of consideration the domestic controls we find that the average amount of arsenic expressed as As_2O_3 in mg. per Kg. of fish, varies from 0.108 to 0.390 in the control fish and from 0.456 to 0.886 mg. per Kg. in the treated fish. May we also recall once more that the maximum arsenic value for all fish considered occurred in an untreated specimen from the Rock River. The values obtained on these bass are much

lower than those obtained by the Swedish Arsenic Commission on untreated marine fish. There maximum value was 4.1 mg., per Kg., and the average 1.3 mg., per Kg. This average for marine fish is much higher than the highest average from our treated fish (0.886 mg. per Kg). Still these marine fish are considered fit for human consumption.

The fatal dose of As_2O_3 for human beings is 60 mg. to 180 mg. (1 to 3 grains). The highest arsenic value for treated fish is 1.38 mg. per Kg. To obtain a minimum lethal dose of As_2O_3 $60 \div 1.38 = 43.4$ Kg. or roughly 85 lbs. of fish: scales, entrails and all would be required.

Since a very considerable portion of the fish is not used for human consumption a quantity of fish far in excess of the 85 pounds just mentioned will be required to obtain a lethal dose. Moreover, since arsenic is eliminated from the body fairly rapidly, this amount of fish would have to be consumed in a very short period of time. (Arsenic was increased in the urin from 0 to 260 milli-milligrams in 3 hours after arsenic had been given orally, Blumendahl loc. cit.). Hence it seems quite evident that the small quantities of arsenic present in these bass fingerlings could not unfit the bass at legal size for human consumption (assuming that the arsenic retention is 100% perfect).

Summary

(1) Wild bass from untreated streams contain appreciable quantities of arsenic (Tables 2 and 4).

(2) The addition of arsenic to water in which bass are kept increases the amount of arsenic in these bass appreciably (Tables 1 and 6).

(3) Bass seem to eliminate arsenic fairly rapidly (Table 6).

(4) Domestic bass and wild bass that have been exposed to arsenic treatment contain on the average less arsenic than do untreated marine fish as reported by the Swedish Arsenic Commission.

(5) The arsenic content in any lot of fish is a very variable quantity.

(6) The maximum arsenic value was obtained from an untreated Rock River fish (Table 2).

(7) According to Sodolin most of the arsenic in the fish is stored in the liver.

(8) The amount of arsenic stored by the bass fingerling is not sufficient to unfit the resulting adult bass for human consumption.

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Discussion

MR. TITCOMB: This paper interests me from the viewpoint of natural reproduction. Do you think that these fish into which you injected arsenic would be affected as to their ovaries?

DR. WIEBE: We did not inject any arsenic into the body cavities of the basses—that was done only with the minnows.

MR. TITCOMB: On one of our shad streams natural reproduction has been practically nullified by the presence in the water of a very minute fraction of arsenic, nicotine and copper. The arsenic occurs as a result of the spraying of tobacco fields in that valley in order to kill cutworms. The nicotine comes from the use of this land year after year in the growing of tobacco, and the copper comes from an industry fifteen or twenty miles away. We found that the eggs would not hatch in the water coming from that river where the fish spawned naturally.

We washed the eggs in water from another hatchery, transported them to that hatchery and were successful in hatching them. When the water in the river became very low we could not hatch the eggs even in the other hatchery, where we got a ninety per cent hatch with the eggs from fish taken in the river. An investigation was carried on by a competent chemist, and we conducted control experiments and ascertained the actual fraction of each of these three ingredients, arsenic, copper and nicotine.

Following the abandonment of that hatchery for two years except for control experiments we found this last year that the ovaries of the shad during low water, after they had been in the river for some time, were affected so that when they expelled what were apparently ripe shad eggs and the eggs were washed in water from a river which was clean, we got the same results that we got from the river where we had our pumping station, and where the presence of this chemical was in evidence. It actually affected the fish before they spawned.

When we got a fresh run of shad during higher water in that river we could take the eggs and hatch them, but under the other conditions even the ovaries were affected before they spawned. I thought it was rather an unusual situation. We do not know which ingredient it is that has the harmful effect—arsenic, nicotine, or copper—but from the observations which have been made I should infer that you might eliminate the arsenic.

Dr. Wiebe spoke about getting arsenic from beer and in the human body. The amount of arsenic you get from beer is no more than you would get from these fish, is it?

DR. WIEBE: Not from ordinary beer. In the manufacture of beer, glucose is used, which is prepared from starch; the starch is changed to glucose by heating with sulphuric acid. The arsenic is originally in the sulphuric acid.

MR. TITCOMB: I do not want to go into that phase of the subject too exhaustively, but we all want to be able to eat more fish, and if four per cent beer doesn't contain any more arsenic than fish I do not know why we shouldn't advocate having a little more good beer.

MR. HOGAN (Arkansas): I would like to ask Mr. Surber what that weed killer costs per acre, and about how many acres they treated?

MR. EUGENE SURBER: The price per gallon f. o. b. Trempealeau, Wisconsin, is fifty-five to sixty-five cents a gallon for the sodium arsenite weed killer. The cost per acre would run around two or three dollars—anyway, less than five dollars.

MR. TITCOMB: May we not have an answer to Dr. Hubbs question? It is an exceedingly important one. We are all preaching vegetation for our ponds.

MR. EUGENE SURBER: I think the main point of Dr. Hubbs question was what procedure should be followed in treating ponds or lakes with this sodium arsenite to keep the vegetation under control.

MR. TITCOMB: No; I think what Dr. Hubbs asked was how you apply it in pond culture, and the reason for it.

MR. EUGENE SURBER: With the ordinary artificial pond you can drain your water down and clean the bottom sufficiently with rakes and so forth, to allow the fish to get down to the algae, but in these sloughs we have to seine them in order to get the fish out in the fall, therefore we cannot allow the vegetation to reach such an excessive abundance as to prevent these seining operations.

We find the best procedure to be to treat the ponds early in spring, in April or early in May, and either to allow the pond to remain untreated for the remainder of the summer, or to treat with smaller concentrations at intervals throughout the summer season. That is the technic we plan to follow in the future. So that we should not attempt to use this sodium arsenite in large lakes until we have more information from smaller ponds.

We should know first, I think, just how important the submerged aquatic vegetation is in our bass ponds and how much vegetation should be allowed to grow in order to afford protection and a sufficient substratum for the aquatic organisms, or for a sufficiently large number of aquatic organisms to live which will in turn furnish an ample supply of food for the fish in the pond. I think that can be determined only by making definite experiments where you have artificial ponds and where you can compare the production of treated ponds with that of untreated ponds. Of course along with that you would have to study the bottom—the quantities of plankton and bottom fauna in both the control and experimental ponds.

MR. TITCOMB: Now if Mr. Langlois will give an answer from his point of view I think we will get the whole of it.

MR. LANGLOIS (Ohio): In Ohio, as I mentioned yesterday, we resort to the method of feeding our bass, and in order that that may be successful it is essential that we get the young bass to take food from the feeder very early in the game. We have found that if there is in the pond an appreciable quantity of coarse vegetation it interferes with our process—the fish have a tendency to hang back in it and do not readily come up and get to taking the food that is offered them. The control of this coarse vegetation, therefore, is absolutely essential.

This year we started a little bit late with the use of sodium arsenite, and it is our intention next spring to start early and try to get the high sign on this vegetation. We have to keep it under control before it really becomes abundant. Incidentally there is in Ohio, not very far from Columbus, an artificial lake, one of the reservoirs of the old Ohio and Erie canal, called Buckeye lake. It is a very popular resort lake, where fishing is just one of the features, boating is next in importance, and swimming last. There are certain protected bays in this lake where the emergent vegetation has become so dense that it is clogging up the bays and rendering them useless for boating.

We have this year experimentally used sodium arsenite in an attempt to open up these bays for the use of the boats. We have not yet much data on the subject, although it is a phase of the application of a chemical treatment to a large lake and as such is somewhat comparable to its application in smaller areas, because of the enclosed nature of the bay.

MR. MURPHREE (Oklahoma): Would there be any danger in using sodium arsenite in large lakes of fifteen or twenty acres from the point of view of the fish being poisoned and made unsuitable for eating purposes?

DR. WIEBE: I see no reason why you could not apply it to the larger bodies of water just as well as to the smaller bodies of water, provided that the people interested in the large body of water are agreeable to it.

MR. MURPHREE: What I want to know is would the fish be poisoned

and made unsuitable for eating purposes after this arsenic was used, for a certain period of time?

DR. WIEBE: The analysis of the fish that Mr. Surber submitted and the data that I have on the subject would indicate that the amount of arsenite used in the treatment of ponds or sloughs is still away below the amount of arsenite found in marine fish which are not treated. I think that will answer the question.

DR. HUBBS: The question that I asked a while ago has been pretty well answered, but I should like to urge a little further caution in the application of this arsenite method in fishing ponds or lakes or in any body of water other than rearing ponds. The major aquatic vegetation is of great value to a lake. For example, in lakes which are very muddy the major aquatic vegetation may provide the only possible solid bottom for the deposition of the fish eggs of forage fish such as golden shiners. Large submerged weeds provide a ground work on which the food organisms will maintain themselves in large numbers. It also provides a place of retreat in which the young fish may seek protection from their enemies, not only the larger fish in the same waters, but the fish eating birds overhead. I think we ought to go pretty slowly in efforts to eradicate or extensively control the aquatic vegetation in large bodies of water, either fishing ponds or lakes.

DR. EMMELINE MOORE: Those are my sentiments too. We have spent a good many years in trying to add to our knowledge of this very important question of the relation of plant life, emerged and submerged vegetation, to the productivity of ponds and lakes.

A COURSE OF SCIENTIFIC INSTRUCTION FOR FISH CULTURAL OFFICERS

W. A. CLEMENS

Director, Pacific Biological Station, Nanaimo, B. C.

It has been appreciated in Canada for many years that the men in charge of hatcheries and their assistants have not had the opportunity of obtaining scientific training such as would better fit them for their important duties; that few realized that they were in a business requiring at least a scientific attitude of mind; that few had caught the vision and could see fish culture from a broad view-point; that perhaps the majority of the men were missing the joys and enthusiasms that might be associated with their duties through lack of training in underlying principles.

Some years ago Dr. A. P. Knight, then Chairman of the Biological Board of Canada, indicated that the Board might undertake to give some instruction to the hatchery officers. The suggestion was met with favour on the part of the Department of Fisheries and in 1925 the Department in association with the Board made arrangements for a course covering a period of two weeks to be given at Truro, N. S., to a group of officers in the Maritime Provinces. During the summer of 1929 the first course, also of two weeks duration, was given on the Pacific coast in Vancouver to the superintendents of hatcheries in the Province of British Columbia. It has occurred to the writer that a brief account of the experiment as carried out on the Pacific coast might be of some interest to the members of the American Fisheries Society.

To indicate something of the character and extent of fish cultural work on the Canadian Pacific coast it may be stated that there are some seventeen fish cultural establishments. The hatcheries are concerned chiefly with the propagation of sockeye salmon. Various other species are handled to a limited extent, including spring, coho and pink salmon, kokinee (little redfish), steelhead, Kamloops trout, cutthroat trout, eastern speckled trout and, in past years, Atlantic salmon. Fish cultural operations in past years have also included the introduction of small-mouthed black bass and eastern whitefish. According to the records the hatchery output in eggs and fry during 1929 was as follows:

Cutthroat trout	212,324
Kamloops trout	3,404,256
Steelhead trout	637,133
Sockeye salmon	96,914,105
Spring salmon	1,535,280
Kokinee	264,000
Whitefish	4,680,000

In addition, 484,245 cutthroat eggs imported from Montana were distributed.

In July, 1929, twelve superintendents and the supervisor of hatcheries in British Columbia met at the University of British Columbia, Vancouver, B. C. The instructors were: Mr. D. B. Finn, Director of the Fisheries Experimental Staiton, Prince Rupert, who presented the subjects of physics and Chemistry; Dr. R. E. Foerster, Associate Biologist in charge of investigations on the propagation of sockeye salmon at Cultus Lake, B. C., who was assigned the topics of fish culture and fish diseases; and the writer, who was responsible for the instruction in general biology, anatomy and physiology of fish and the identification of the fresh water fish of British Columbia.

The instruction was given in the form of more or less informal talks, supplemented by demonstrations, and practical work on the part of the men wherever possible. The content of the course was as follows:

Physics and Chemistry. Nature of matter, living and non-living. Chemical changes—elements, compounds, mixtures. Energy changes—heat, temperature, measurements, transmission of heat, heat and living processes. Calibration of thermometer, Fahrenheit and Centigrade scales, construction of conversion chart. Gases and the atmosphere—importance of various gases in life processes, atmospheric pressure, barometer. Liquids—water, ice, solutions, diffusion, osmosis, density, specific gravity, hydrometer. Evaporation—water and the atmosphere, humidity. Dissolved gases of water; water in relation to living organisms. Acids, bases, salts, occurrence in streams, lakes, ocean. Acidity and alkalinity with introduction to meaning of pH and its measurement. Chemistry and physiology of the cell. Relation of chemistry and physics to life and the application of this knowledge to work in fish culture.

Fish Culture. Spawning-migration, reproductive organs and processes, embryology, later development, relation of physico-chemical conditions to development. Food-types, natural

food organisms, food chains, foods and feeding habits of fish, especially salmon and trout. Comparison of bodies of water —river, lakes, ponds, temperatures, stratification, overturn, oxygen, carbon dioxide, acidity. Productivity of bodies of water. Fish associations—predators, competitors. Downstream migrations. Natural propagation. Artificial propagation, hatchery equipment, water supply, care of eggs and fry, feeding, artificial foods, distribution of hatchery product. Practical work: Dissection of reproductive systems of salmon, demonstrations of embryological development, examination and identification of food organisms—plankton and invertebrate groups.

Fish Diseases. Nature and types of disease, fungal, bacterial, protozoal and deficiency diseases, causes. Reparative processes, healing of wounds, processes in inflammation. Treatment of disease—curative and palliative measures, disinfection and cleanliness.

General Biology, Anatomy and Physiology. General structure and life processes of plants and animals. Structure and functions of integumental, digestive, respiratory, circulatory, execretory. reproductive, skeletel muscular and nervous systems of fish. Sense organs. Fish Fauna—classification, distribution, life histories and economic status of the fresh water fishes of British Columbia. Principles and problems in conservation. Practical work: Manipulation of microscope, dissection of organ systems of salmon, examination of simple histological preparations, identification of fish by means of keys.

Discussion period. Each afternoon for an hour or more an informal discussion took place on a selected topic. Among the subject discussed were:

Proportion of sockeye salmon males to females in nature on the spawning beds and the efficiency of fertilization under natural conditions.

Survival time of milt and the period of time in which eggs may be fertilized after expression.

Relative merits of expressions and incision methods in spawning of salmon.

Hardening and care of eggs.

Movement of eggs during incubation period.

The use of ponds in the artificial propagation of salmon and trout.

The artificial feeding of fish.

The planting of eggs and fry.

Hybridization among Pacific salmon.

Fish enemies.

Introduction of non-indigenous fish.
Pollutions and power dams.

The course was concluded with a special address given by Dr. H. B. Ward of the University of Illinois on "The Conservation of Pacific Salmon."

While the above course may appear formidable on paper, it should be borne in mind that the material was presented in a simple, informal and elementary manner. The aim in the instruction was to present a broad viewpoint in fish culture, to indicate some of the fundamental facts underlying the subject and to emphasize the scientific method and attitude of mind. At the same time a certain amount of information more or less directly related to routine work in hatchery practise was given.

The reactions toward the instruction on the part of the superintendents were so encouraging that it was considered desirable to have the course given to the hatchery assistants. Accordingly, in 1930, the Department of Fisheries arranged with the Biological Board to have instruction given along more or less similar lines to these men. The special lecturer in this year was Professor R. A. Wardle of the University of Manitoba, who spoke on "The Value of Fisheries Research."

The logical development of the work seemed to call for instruction in the field. It seemed desirable to have the men actually use various pieces of apparatus, to make observations, to collect data and materials and to study these at first hand. Recommendations to this effect met with approval and arrangements were made in 1931 for a two-weeks period of instruction in the field for the superintendents of hatcheries. Shuswap lake in the interior of the Province and on the Fraser river drainage system was selected. This is a lake in which there are large numbers of salmon, trout and other fish and it was considered particularly suitable for providing materials for study and for affording scope in instruction.

The lake has an area of approximately 106 square miles and is very irregular in outline. It was obviously impossible to study the lake in its entirety and operations were accordingly confined to the outlet region. Satisfactory accommodations were obtained and an unoccupied farm house nearby on the lake shore was secured for use as a laboratory. Two motor boats and two row boats were available for use at all times.

The group was divided into two sections, facilitating instruction in the field and in the laboratory. Details of pro-

cedure need not be described here except to state that each man was required to use each piece of apparatus, to identify the materials collected and to keep complete records. The field equipment included surveying instruments, reversing and other thermometers, water bottles, grab and drag dredges, plankton, dip, seine and gill nets, hydrogen-ion colorimetric sets, transparency and turbidity instruments, and apparatus for oxygen determination.

The instructors in this year were Dr. N. M. Carter, Chemist on the staff of the Pacific Biological Station, Dr. R. E. Foerster and the writer.

The following is a brief outline of the course as given:

Physics and Chemistry—more or less along the lines of the previous courses. Map work—topography and geology of the area, formation of lake and streams, characteristics of surrounding country in relation to the character of the water, sounding and contouring of lake bottom. Hydrography—reversing water bottle and thermometers, temperatures, stratification, currents; streams—water-shed area, velocity, volume. Water analysis—dissolved oxygen, pH, transparency, colour, turbidity. Meteorology—sunshine, rainfall, temperature, relative humidity, wind; relation of these to the physico-chemical features of the lake. Records—tabulations, graphs, etc.

Biology. Vegetation—vascular plants and larger algae, identification and methods of preservation, distribution importance in economy of lake. Plankton—methods of collecting, quantitative methods, identification of common forms, importance of plankton in economy of lake. Invertebrates of lake shore, of lake bottom, of streams—collection, quantitative methods, identification, life histories, adaptations, economic importance. Fish—collection with seines and gill nets, identification, use of keys, life histories, distribution, examination of stomach contents, inter-relations among fish population.

Evening lectures and informal discussions,—

The tagging of salmon.

Salmon investigations at Cultus lake and Eagle river.

The work of the conservation commission of the State of New York.

The fish fauna of British Columbia—its origin and characteristics.

The handling of eggs at hatcheries.

Water flow and trough capacity.

The use of ponds in artificial propagation.

Meteorological instruments and records.

During the period a special lecture was given by Dr. D. S. Rawson of the University of Saskatchewan on "The Productivity of Lakes."

If interest and enthusiasm be any criterion, this field course may be judged to have been a success. It is difficult to set down tangible results but there would seem to be reason to believe that the instruction of the two periods has fully justified the expenditure of time, effort and funds. The acquisition of a certain amount of information and the appreciation of the "why" and the "wherefore" of ordinary routine operations should promote a better understanding of the work of fish culture and more efficient practise. The attainment of a scientific attitude of mind is of even greater importance and should make for sound progress. Furthermore, the value should not be overlooked of personal contacts among the men during the two weeks when individual experiences are exchanged and problems discussed. The contribution toward the building up of an *espirit de corps* should be considerable. Short term instruction would appear to be a step toward the attainment of an ideal condition in which all fish cultural officers will be in the possession of thorough scientific training.

Discussion

MR. TITCOMB: We always know that when Dr. Clemens presents a paper we have got something good. Do I understand that these superintendents are called away from their duties to assemble for a period of six weeks for a conference of that kind?

MR. RODD: Up to the present they have been assembled for two weeks, which so far has been the duration of the courses. The first year of the course is designed for superintendents and the next year for those below the rank of superintendent, and it is confined to British Columbia on the west and the Maritime Provinces on the east. We are considering another course of six weeks duration, to be given in January and February of 1932.

MR. TITCOMB: I think that is a mighty good thing, and it must be very inspiring to the superintendents who are capable of grasping the material. But I have in mind states where the assembly of a dozen superintendents for a course like that would not amount to much. It might sift out the more intelligent and enterprising from the others and wake them up so that in the end there would be a gradual improvement, but I would go further than Dr. Clemens has gone: I would have a symposium at every hatchery and call in every employee to discuss the more elementary phases of the work—why they do certain things; why certain species are placed in certain waters; the importance

of a permanent stocking policy, and all the more elementary ideas which every one of them ought to know about. There is a great opportunity right there, to take the hatchery employees, five or six men, have an hour a week with them, get them to feel like asking questions, and thus perhaps get them more into the spirit of the thing and out of the idea that they are nothing but ditch diggers and plumbers.

Mr. Rodd: The course was very elementary in character, dealing with the points of actual hatchery practice, the reasons for placing certain fish in certain areas, and so forth. The full confidence of the men was obtained by Dr. Clemens and those associated with him, so that those who attended the courses are anxious to come again and feel that they get something out of it. Some of the men, of course, naturally got great deal more out of it than others.

THE CULTURE OF CHANNEL CAT FISH
(*ICTALURAS PUNCTATUS*)

BEN E. MOBLEY, WARDEN

Oklahoma Game and Fish Commission

The Channel Cat is a native to all Oklahoma streams and compares favorably with the large-mouth black bass in gameness. It is unsurpassed as a food fish.

Considering these values, the Oklahoma Game and Fish Commission feels justified in making plans to enter into the propagation of Channel Cat on a large scale.

For the past six years the propagation of Channel Cat has been confined to our state fish hatchery located at Durant, Oklahoma, under the supervision of Fish Culturist J. M. Murphree.

Mr. Murphree and his assistant, Mr. V. C. Graham, have constructed, out of one-inch poultry wire, a series of twenty-one pens. These pens are twelve feet wide and extend out from the bank to a distance of ten or twelve feet. A common nail keg, with a small amount of gravel in it is staked down eighteen inches under the water, to be used as a nest. One pair is placed in each of the twenty-one pens. Kegs are placed in the pond for the remainder of the breeders.

The male prepares the nest by removing the gravel. The female spawns from 10,000 to 20,000 eggs. The male assumes the duty of protector and will always be found on the nest, except when leaving for food, which consists of beef liver.

The eggs hatch in seven to nine days. The young fish are removed to the nursery ponds in six or seven days after hatching.

The female, after the spawning period, is released into the pond, and another ripe female is taken from the pond and placed in the pen with the male. Some of the males have taken care of as many as three spawns of eggs in a season.

When a spawn of eggs is found in one of the kegs in the open area of the pond, the keg and attending males are removed to a trough, which has running water. This precaution is taken to prevent the destruction of eggs by other fish.

In several instances the male could not be trapped and moved with the keg, making it necessary to take a male away from the nest of eggs he had fertilized and was then caring for, and place him in a keg with another fertilized spawn of

eggs; he willingly accepts the new duty and guards them, as he did the eggs he had fertilized.

Small Channel Cat demand more attention than young bass. It is necessary to feed them once a day, over a period of four months. The daphnia that is placed in the culture pond aids in supplying the food while the fish are quite small; but it is also necessary to feed them dried skimmed milk and cod liver oil as soon as they are moved to the culture pond. A pound of milk, mixed with an ounce of oil, is considered a daily ration for two thousand young fish. At the age of six weeks, ground beef liver is added to the dried milk and oil diet. This diet produces four inch fish for October delivery.

There seems to be only one parasitic protozoan from which we have had any loss, and that is the Ichthyophthirius Multifiliis. This disease appeared in one pond in 1923 and in two ponds in 1924. During these two years several different treatments were tried without much success, there being a total loss in these ponds. This disease in most cases starts in the warmer part of the summer—about the middle of August—and the fish survive only about ten to fifteen days after the disease appears.

In 1925 the parasite again appeared in these two ponds. This time a treatment of copper sulphate and iodine was administered to the entire pond, which is thirty feet by fifty feet in area and three feet deep in the center. Eight pounds of copper sulphate and a small amount of iodine in a sack was applied by wading around in the pond and stirring the sack in the water. In about five minutes the fish begin coming to the surface for air. This is the signal for the fresh water to be turned in and the drain opened so that the treated water can run out. The solution was strong enough to cause the epidermis to shed from the fish in twenty-four hours, thus leaving the fish free from the disease. As soon as the fresh water is turned into the pond, the fish move to the stream of fresh water, which is allowed to run in until the water in the pond is again clear. After this treatment, the fish are fed within forty-eight hours. With this treatment the disease has never re-appeared in the pond in the same year.

Oklahoma, this year, will far surpass any previous year in Channel catfish production. After the seven culture ponds at the hatchery were filled, a surplus of eighty-two thousand was delivered to nursery ponds in various sections of the state. The results, however, do not compare favorably with bass fry placed in culture ponds, due to the lack of proper attention and feeding, which the young Channel catfish require.

Discussion

PRESIDENT LECOMPTE: I understand you to say you feed ground liver?

MR. MCMURTREY: Ground beef liver.

MR. TITCOMB: Is there much cannibalism among the young fingerlings?

MR. MURPHREE (Oklahoma): No sir, they get along quite agreeably when they are placed in a rearing pond away from the adult fish. That is the method we use in rearing them to fingerling length. They begin to feed on milk after they attain an age of about ten days; we start feeding them dried skimmed milk mixed with cod liver oil, as explained in the report, and there is no loss from cannibalism.

MR. LANGLOIS (Ohio): I spoke yesterday in my paper of the salt treatment of bass for this same parasitic protozoan, with good results. I did not mention, however, that in the same pond we had a considerable number of young marble catfish, or yellow bullheads, and these bullheads were subjected to the same salt treatment, as a result of which many of them died. They sloughed their epithelium just as these fish did, and I was wondering if the gentleman from Oklahoma experienced a loss of his catfish as a result of this treatment.

MR. MURPHREE: During the last two years, since I began to use the iodine mixture with a solution of sulphate of copper, a treatment which causes the slime to come off the fish, the loss has not been very great—probably seven or eight per cent when treated in a pond with fresh water run in after the treatment is commenced.

ELECTRICITY AS A MEANS OF GARFISH AND CARP CONTROL

J. G. Burr

Director of Research, Texas Game, Fish and Oyster Commission.

Freshwater fish in many parts of the United States were becoming scarce fifty years ago. The United States fish commissioner introduced German carp and planted them in every state that was progressive enough to want them. It was loudly proclaimed that German carp was the most popular fish in Europe, and believe it or not, the idea took firm hold in the United States that carp would become as common and plentiful as pigs and poultry. If Ripley has not already mentioned this he has overlooked something. There was even some controversy as to who claimed the honor of being the first to introduce this fish.

The first fish hatchery in Texas was built in Austin in 1880 for the propagation of carp. The hatchery was abolished by the legislature four years later, and since that time we have been trying to abolish carp. Others of our poor oppressed foreigners were the English sparrow and the starling. A biological cry of America for Americans would be highly appropriate, but we must not forget that garfishes are not European but are descended from the oldest American families.

The problem today is to control carp and garfish. Electricity offers large possibilities in the undertaking.

On the face of it this looks like a most interesting subject. Electricity is doing so many things and doing them so easily that we are prepared to believe that its possibilities are unlimited. When I tell you that garfish can be killed by electricity, and that other fishes are merely stunned, when the proper amount of current is used, and that useless fishes, such as carp, can be lifted from the water with dip nets, leaving other useful fishes to swim away in two or three minutes, there is likely to be a sigh of relief that all our troubles are soon to be ended. But electricity, like everything else, must work within limits, and this paper deals with the limits, as far as known by the writer at this time, without attempting to say what will be possible hereafter.

Direct current is not at all adapted to stunning fish, and only alternating current, of not less than 60 cycles, should be used, Any voltage from 100 up can be used, according to

the area of water that is to be charged, the degree of the shock being controlled by the distance between the electrodes in the water which is more fully explained later. There are several ways to use the current, not only for killing garfish, but for stunning and removing useless fish from the water. It is sometimes possible to use a power line.

In a small body of water, not over 150 feet wide or over 15 feet deep, carp and other fishes when stunned float to the surface where they soon recover, while garfish are stunned and sink to the bottom where they die of strangulation because they have no swim bladder. The gar has a contractile muscle in its arterial bulb, which is absent from other fishes, which probably augments the process of suffocation. Also the gar has a lung, or something resembling one and, in warm weather, takes a portion of its oxygen from the air at the surface of the water. If the stunned gar cannot get to the surface to take air, it will die within half an hour or so because the gills do not supply sufficient oxygen. On the other hand a gar, in warm weather, can remain under water 12 hours when its lung is undisturbed by an electric current. In cool weather they are rarely seen at the surface.

Laboratory experiments show that gars, electrocuted in midsummer when the water is warm, die much quicker than they do in the late fall when the water is cooler. I was puzzled quite a bit to find that the gar died in 30 minutes, after being shocked, when the temperature was around 85, and that in a temperature between 65 and 70 it took the gar five or six times as long to die. When a gar is hit by the current, it lies on the bottom, on its side or back, working its gills. If there is a greater quantity of oxygen present in the water by reason of the low temperature, the death struggle of the gar is prolonged accordingly. I am not prepared to say how successful it would be to attempt to operate in an extremely low temperature, I do know that more shocking power would be needed. As to the stunning of fish, it should be said that in laboratory experiments fish do not float. Handling of them seems to reduce bladder buoyancy.

The method of operating in a small body of water, is as follows: Use 400 volts, more or less, from a power line, sending the current through two wires, one of them zigzagged across the bottom of the lake or stream with lines of the angles not more than 60 feet apart, and the other line, attached to buoys or light planks, may be dragged over the surface by men stationed on each side of the body of water. It is perfectly safe for the men in a skiff to remove the stunned

fish with dip nets, though it is best to remain three or four feet away from the floating wire. The hand in the water at that distance has only a tingling sensation, and the deeper one goes the more severe it gets. In connecting the ground, it is necessary to pass the current through a barrel of brine to bring down the amperage.

Tail races below river dams are fine concentration places for gar and carp at certain times of spring or summer. A better way to work in such a place is to stretch two wires, of one or two hundred volts, just above the surface of the water, and from them drop wires alternately every two or three feet in the water to a depth of two or three feet. In this way the line is stationary and the current is fixed. Such a current will paralyze fish and gar over a path of 100 or more feet by 10 feet wide. The current must be turned on and off as occasion requires but should not be kept on over a minute or two at a time. The edible fish can stand more than that ordinarily, but certain catfishes, excepting the yellow cat, do not float when stunned and too long a time under the current would be fatal. Some such plan was used this summer in the Pecos River at Roswell, New Mexico, with good results, according to J. G. McGhee, a member of the New Mexico Game and Fish Commission.

Our most important experiment was made at Sugarland a year ago with the cooperation of the Sugarland Industries Inc. Without being able to build an outfit in every way adapted to the purpose, a floating machine was assembled of such materials as were at hand, and launched in a canal. On a barge eight feet wide by sixteen feet long, engines and a generator of 200 volts were placed, and alligator gars were thus apparently exterminated from the small canal.

With this method the electrocuted gars could be counted exactly, for the barge carried in front a seine 20 feet long for picking them up, which could be raised by levers and emptied. During the experiment 75 alligator gars and 1,000 hard shelled turtles were picked up in the seine. The barge was equipped with a bright headlight which blinded both gars and turtles so that they made no effort to escape. The seine was hung in a right-angled frame two and half feet in the water, as gars at night usually swim near the surface while feeding. The wiring was attached to the back of the seine frame, with electrodes two to four feet apart delivering from 15 to 30 amperes, either distance being effective.

The canal was less than a mile long by 100 feet wide and 10 feet deep and evidently had few gars in it. On a nearby

farm the goslings which swam in the canal were being devoured by gars, it was said, but after the clean-up the goslings were turned out without being molested.

It was suggested that the seine should be able to pick up the gars without the aid of the current but this was found to be impossible. They broke through it, jumped over it, or turned out and outran the boat after striking the seine. Nothing but the electric current could tame them.

With plenty of open water and no obstruction, this device is easily handled, but further experimentation indicates that a way may be found to operate a floating craft without the inconvenience of a seine and send the gars to the bottom. This could be used day or night and in deep water, charged with current to a depth of 15 feet, to destroy garfish or to remove carp and buffalo. Such a plan involves a floating device without seine but with adjustable electrodes carrying a current deadly enough to kill gars on the bottom of the lake and harmless enough to bring all fish to the surface for proper disposition. What it is possible to do with a higher cycle current is explained as follows:

When we began experimenting with the stunning of fish and garfish we used a 60 cycle alternating current with stress on the importance of doing no permanent harm to the useful fishes. The amount of voltage and current was carefully measured and it was found that the useful fishes generally stand about ten times as much as a garfish. This left a wide margin of safety for useful fishes and on first thought there seemed to be nothing left for future discovery as to the proper current. But in the language of Hamlet, there are more things in heaven and earth than we have dreamed of and we began wondering what might happen if we tried out the higher cycles. This was only an idle thought in the interest of pure science which could have no practical value. We tried it, using 250 cycles and were horrified at the shocking power. It gave more than we needed and seemed too dangerous to be used on fish. But power is a great thing if it can be regulated and if you can make two shocks grow where one grew before, why not cut the investment in half and still have the same amount of shock. That is, if 200 volts of higher cycles will do what 400 volts of 60 cycles will do, the investment in current is cut one half. By actual laboratory test we found that a 350 cycle current gives fish a shock three times as great as that of the 60 cycle current. That is, it took fish three times as long to recover from the shock. It was further found that above 350 cycles, or there-

abouts, the force of the current began to weaken and that at 630 cycles the fish was helpless only while the current was on and immediately righted itself when the current was off. We used water of a density of 1.00114 specific gravity at a temperature of 17,8 c., with a 15.56/15.56 hydrometer. This was very high density, the water coming from a mineral well.

The density of the water used was more than double that of ordinary water, so we diluted it with distilled water cutting the density to one-half and proceeded to measure the current and its effect. The lower density carried only one-half the current of the higher density but had greater shocking power. Any electrician understands that a fish offers greater resistance to the current than the mineral in the water, and where the mineral content is greater the current takes hold of the fish with less effect. In a brackish creek with 6,400 p.p.m. of salt, it was found that only a faint shock was produced by a 200 volts 60 cycle current but no doubt a 350 cycle current would have produced practical results, and certainly so if 400 volts were used. However, in all normal waters there is no difficulty in making practical use of the current.

As stated, the 60 cycle current was used in all operations, outside of the laboratory. Stock generators of the 60 cycle kind can be bought at the factory ready for use, but the higher 350 cycle generator must be built to order which entails a slight increase in price, but is more economical in the end.

For those interested in what can be done with the higher 350 cycle force, we give some tests on fish that were made in the laboratory of the Agricultural and Mechanical College at Bryan, Texas, with the assistance of Prof. Norman F. Rode.

We used a trough 1 foot deep by 2 feet wide and 7½ feet long. The mineral water used was diluted to one-half the density mentioned, giving fairly typical water. Voltage used in the experiments ranged from one to two hundred and the cycles were 60 and 350. The electrodes were placed successively at a distance of two, four, six and 7½ feet. The current was put on for 15 seconds only. Our strongest current, 200 volts, 350 cycles and 2.95 amperes with electrodes at a distance of two feet stunned a crappie, a sunfish, a bowfin and a silver side. The sunfish was up in 7 minutes, the crappie in 9 minutes, the bowfin in 9 minutes and the silver side in 10 minutes. A crappie given a much longer shot did not recover for 50 minutes. No bass were available in the experiment but other tests showed that the bass and crappie have a similar resistance. With the electrodes at a distance of two

feet the margin of safety for fish is very small. (In a former experiment with electrodes, one foot apart, a 100 volt 60 cycle current of less than one ampere killed a bass outright). Doubling the distance from the electrodes to four feet with 350 cycles and 200 volts the current dropped to 1.95 amperes or about one-half. When stunned the crappie was up in 4 minutes, the silver side in 4 minutes, and another minnow in 3 minutes. Again nearly doubling the distance between electrodes, 7½ feet, with the same cycles and voltage there was a further drop to 1.07 amperes. The crappie was up in two minutes, the silver side in two minutes and the bowfin in seven minutes, but another minnow did not turn over. The bowfin, a cousin of the gar family is very sensitive to the current. In both cases where the distances were doubled or nearly so, the period of paralysis was cut about in half for the crappie and silver side.

The use of 100 volts, .53 amps. of 350 cycles indicated that a lower voltage had less to do with the result than the higher cycles in a distance of 7½ feet. Again the silver side was up in two minutes and the bowfin in 6 minutes. The sunfish was near an electrode and was on its back in 6 minutes. Contrasting this result with that of another test with the cycles reduced to 60 we have a different story. The fish were stunned but recovered immediately when the current was lifted.

The following table gives the measurement of amperes at different distances from the electrodes in two densities of water, one of them high and the other about one-half as dense. Ampere readings were the same whether with 60 or 350 cycles.

High Density water. S. G. 1.00114 at 17.8 C., 15.56/15.56

Electrodes		
2 feet apart	100 volts	3.2 amperes
4 (4) " "	" "	2.3 "
6 " "	" "	1.7 "
7½ " "	" "	1.2 "

Electrodes		
2 feet apart	200 volts	6.4 amperes
4 " "	" "	4.6 "
6 " "	" "	3.4 "
7½ " "	" "	2.5 "

Water with half that density or less.

Electrodes		
2 feet apart	100 volts,	1.42 amperes
4 " "	" "	.93 "
6 " "	" "	.61 "
7½ " "	" "	.5 "

Electrodes		
2 feet apart	200 volts,	3. amperes
4 " "	" "	2.05 "
6 " "	" "	1.3 "
7½" "	" "	1.05 "

A 60 cycle 100 volt current should have the electrodes 2 feet apart, a 200 volt current 3 feet apart for effective work, but a 350 cycle current works well with the electrodes 7½ or 8 feet apart using about one-third as much current to do the work as would be used with a 60 cycle current. If the higher cycles have three times the potency of the ordinary current, a saving of two-thirds of the power cost would result. This has reference only to a floating generator where much power is needed. In other cases a power line of 60 cycles is satisfactory.

In charging an average body of water the amount of current used is increased 50 per cent each time the area to be changed is doubled. For example, if electrodes were hung in the water 3 feet apart along the wires for a distance of 21 feet and the electrodes entered the water to a depth of two feet, 200 volts would give you about 14 amperes. If the line were doubled to 42 feet with corresponding electrodes, there would be 21 amperes. If the length of the electrodes were increased to 4 feet of depth in the water, there would be another 50 per cent increase of current, or about 30 amperes. There would, of course, be variations caused by the density of the water, but for average water the rule holds good. In using the 350 cycles the electrodes may be used six to eight feet apart as needed. The current will corrode the wires after a few hours' use in the water but this can be prevented by first dipping the wires in bi-chloride of mercury.

If garfish are to be killed by a floating device designed to send the gars to the bottom, they should be given the most severe treatment when the current is moved rapidly through the water. The super 350 cycle current, 200 volts driving some 30 amperes, would work effectively in 15 feet of water over a path 40 feet wide, in removing carp. In killing garfish, if they are to be allowed to fall to the bottom, it would be necessary to make some test to determine the proper speed of the craft for delivering the fatal shock. The time element complicates matters, but the power can be increased by narrowing the distance between electrodes, thus permitting greater speed. We have never tried to kill gar on the 350 cycle but since one ampere of a 60 cycle 100 volt current applied for 15 seconds is fatal, it is reasonable to expect that

twice that voltage with 350 cycles would be fatal in a shock lasting two seconds. A speed of about two miles an hour would give two seconds within the space of the electrified zone. In dealing with carp much higher speed is possible. The higher cycles have never been used in the open waters but I am convinced that practical use will be made of this method.

A machine of the potency described can be bought for about one thousand dollars which would include a generator and engine combined on the same base, together with the meters. The department will be glad to aid in any way possible in the introduction of this work, and believes that the time is coming when a definite program of gar and carp control must be entered upon in Texas and in other states.

Discussion

MR. LAIRD (Long Island): If you had some kind of bait for the gar to feed on, would he come up and try to take it?

MR. BURR: He wouldn't as long as the current was on. When the gar or other fish are there, put your current on. During the winter I tried putting some kind of lure under the wire. I took a five gallon glass jug, filled it with minnows and water and hung it right under the wire, thinking they would come around and try to get the minnows. I don't know whether I got any of them or not, because I didn't stay there very long.

MR. VIOSCA (Louisiana): It is very probable—I am talking theoretically right now—that the effect of the current is to disturb the organs of equilibrium of the gar—that is, the lateral line of the system, and that it may shock the system and have no other effect on the fish.

MR. BURR: I took home some bass and crappie which had been within the area of the 250 cycle shock, put them in a trough and kept them there four months to see if they got along all right, and they did.

PRESIDENT LECOMPTE: I thought the electric shock killed the fish?

MR. BURR: No, these were good fish, bass and crappie. I wasn't killing any of those.

PRESIDENT LECOMPTE: What is it you dip the wires in?

MR. BURR: Bi-chloride of mercury.

MR. TITCOMB: Do you mean by mullets what we call suckers?

MR. BURR: These mullets I was working with were in a slough down near the coast, and I imagine they belonged to the salt water mullet family.

DR. HUBBS: That would be the ordinary striped mullet, not the fresh water mullet.

MR. MURPHREE: How far out from your electrodes does the current affect the fish?

Mr. Burr: With 200 volts and a 60 cycle current, the fish begin to realize that all is not well about four feet away. When surprised by the current they are just as apt to swim into it as to swim away from it; they do not know where it is coming from.

Mr. Chute: Did you notice whether or not there were any external parasites on the fish you returned to the water, and if so do you think the electrical current would have the effect of cleaning them off?

Mr. Hazzard: Did the current kill or stun the smaller gar and carp, or only the larger ones, or both?

Mr. Burr: The smaller the fish is, the harder it is to affect by the current. I knew one crappie to be stunned and to remain unconscious for fifty minutes, but ordinarily they come out of it in two to five minutes, depending on the duration of the shock. It is not necessary to kill any of the desirable species of fish, but it is very easy to kill the gars.

Mr. Hazzard: So that your system of eradication would tend only to kill off the larger adult fish; you could not hope to clean out the fish in any particular area?

Mr. Burr: Oh yes, it doesn't matter how small they are—it will stun any fish. I merely mentioned that the smaller the fish the less the effect of the current is; there is less current to strike the fish, or there is a smaller area to receive the current. For example, it is very difficult to stun minnows or turn them over, but you can stun them if you have sufficient current.

THE DESTRUCTION OF GREY TROUT EGGS BY SUCKERS AND BULLHEADS

N. J. ATKINSON

Biologist, Lucerne-in-Quebec Community Association, Limited

Although suckers have been casually reported for some years (see discussion, Trans. Amer. Fish. Soc. Vol. 59, p. 267) as eating trout eggs there has been, up to the present, a complete lack of quantitative data on this subject. During the summer of 1930, in the course of an investigation of the waters of the Lucerne-in-Quebec Community Association, Limited, persistent reports of the consumption of trout eggs by suckers were received from local fishermen and an investigation was made in October and November with the results given below.

Commandant Lake, where the investigations were made, lies in the Laurentians, forty-five miles east of Ottawa and with the southern end or outlet eleven miles north of the Ottawa River. The lake is seven and one-half miles long, with a maximum width of slightly over two miles and a large number of bays and islands. A considerable part of the lake is over one hundred and fifty feet deep though extensive shallow areas also occur.

All observations were made on one typical grey trout (*Cristivomer namaycush* Walb,) spawning bed on a sheltered shoal near the middle of the lake. Fish were taken with a four foot deep fyke net with forty-two foot wings which was set in the same position each night that observations were made, the mouth facing the main spawning ground, with one wing running out in about two feet of water, the other in about five feet. A preliminary examination of the bed was made on the night of October 21st, when trout were present in fair numbers but had apparently only just started to spawn. Spawning fish were present in large numbers on the night of October 29th, this about the height of the period. The last night on which trout were seen on the bed was November 11th. The total catches of fish are shown in Table 1. The species involved were the common bullhead, *Ameiurus nebulosus* LeSueur,* and the common sucker, *Catostomus commersonii* Lacepede.

*Determination by Dr. Carl L. Hubbs.

TABLE 1

TOTAL CATCHES OF BULLHEADS AND SUCKERS

Date	Bullheads	Suckers	Surface Temp.
25/X	109	5	51° F.
29/X	67	14	49
5/XI	3	43	47
13/XI	10	0	45
21/XI	9	0	45

Analyses were made of the fresh stomach contents of the fish. Where the catch was large, twenty-five bullheads and ten suckers were taken as the standard, the samples selected being representative in size of the whole catch. The reason for the different unit samples is the much greater labour involved in the examination of the sucker intestines. The summarized results are given in Table II.

TABLE II

BULLHEADS AND SUCKERS

Number of grey trout eggs and egg shells in digestive tract

Date	No. of fish dissected	No. of fish with trout eggs or shells	Total No. of eggs	Ave. no. of eggs per fish that had eaten any	Greatest no. of eggs in any fish	Weight and Sex of this fish
BULLHEADS:						
25/X	25	8	239	30	74	8 oz. Female
29/X	25	18	1083	60	178	4 " "
5/XI	3	3	19	6	11	8 " Male
13/XI	10	5	128	26	60	4 " Female
21/XI	9	2	36	18	35	2 " "
SUCKERS:						
25/X	5	2	71	36	40	8 oz. Male
29/X	14	8	580	73	172	2 lb. 2 " Female
5/XI	10	8	826	103	466	2 " 3 " "

Table III and IV show the numbers of trout eggs and shells found in the digestive tracts with the fish classified in weight groups.

TABLE III

Bullheads: number of eggs found in various sized fish

Weight of Fish. oz.	16 – 12		11 – 8		7 – 4		Under 4	
Date	No. of Fish	No. of Eggs	No. of Fish	No. of Eggs	No. of Fish	No. of Eggs	No. of Fish	No. of Eggs
25/X	5	39	5	74	12	126	3	0
29/X	2	62	6	334	15	640	2	47
5/XI	0	0	1	11	2	8	0	0
13/XI	0	0	0	0	2	60	8	68
21/XI	0	0	0	0	6	1	3	35
Total	7	101	12	419	37	835	16	150
Average		16		35		23		9

TABLE IV

Suckers: number of eggs found in various sized fish.

Weight of Fish	2 lbs 8 oz – 2 lbs		1 lb 15 oz – 1 lb 8 oz		1 lb 7 oz – 1 lb		15 oz –8 oz		Under 8 oz	
	No. of Fish	No. of Eggs	No. of Fish	No of Eggs	No. of Fish	No. of Eggs	No. of Fish	No. of Eggs	No. of Fish	No. of Eggs
25/X	0	0	1	0	1	31	1	40	2	0
29/X	1	172	3	341	2	45	5	46	2	15
5/XI	1	466	2	62	1	123	4	172	2	3
Total	2	638	6	403	4	199	10	258	6	18
Average		319		67		50		26		3

Discussion of Data

The figures presented bring out the following facts: that grey trout eggs may be consumed in large numbers by bullheads and suckers, the highest figures found being 178 eggs and shells in one bullhead and 466 eggs and shells in one sucker; in this particular fish, the anterior ten inches of the forty-two inch long digestive tract were empty while the eggs extended right to the anus and some had probably been passed: that the medium sized bullheads consume more eggs

than the largest or smallest: that the largest suckers (and though not shown in the summarized data presented, these were generally females) consume many more eggs than the smaller.

No explanation is evident for the changes in the total number of fish caught, as shown in Table 1. Superficially, it would appear that the suckers chased away the bullheads but no evidence of this was seen in the field. The greater number of eggs eaten by the medium sized bullheads is connected presumably with the shape of the mouth, the larger fish, with their very large mouths, finding difficulty in reaching the eggs lying between the stones. The suckers, on the other hand, with their protractile mouths, apparently experience no difficulty in this respect.

No indications of any of the fish interfering with one another were observed. All three species were seen on the beds at the same time though the trout were rather more easily disturbed by the flashlight beam than the other fish. No fish were ever seen on the bed during the day but the presence or absence of the moon did not have any noticeable effect.

The actual economic loss occasioned by the bullheads and suckers is probably not as high in this water as might at first seem evident since there is, apparently, among the adult trout, a considerable competition for the food supply. If this last can be increased, however, it will certainly be necessary to try to reduce the number of spawn-eaters. In conclusion, it should be pointed out that the observations are for one year on one spawning bed and too wide generalizations should not be drawn from them.

Discussion

Mr. Rodd: Mr. Atkinson is biologist for the Lucerne-in-Quebec Community Association, which has exclusive rights of fishing and hunting on an area of 80,000 acres. It is located on an area of historic significance, dating back to the French era, the tract having been granted by the then King of France to one of the seigneurs.

This question came up at the Minneapolis meeting, and as I recall it, the sucker was very largely exonerated. We have found on several occasions indications of damage by the sucker to the spawning grounds of trout. Mr. Atkinson's observations cover one lake, one spawning ground, and one season.

Dr. Hubbs: Is the gray trout the lake trout?

Mr. Rodd: Yes.

DR. HUBBS: What is the nature of the spawning bed in the lake?

MR. RODD: It is largely coarse gravel, with an admixture of sand, characteristic of the Gatineau district in which this trout is located.

DR. HUBBS: Is it the custom of the lake trout to bury the eggs to a considerable depth in the gravel?

MR. RODD: I do not think so; there is no indication of burying.

DR. HUBBS: This problem, of course, is very different from the problem in streams—for example, the eating of brook trout eggs by suckers at night. It is our intention in Michigan this fall to try to determine whether or not suckers are feeding on the brook trout eggs in the streams. We tried once to determine whether they did or not, and we were unable to obtain from the spawning beds of the trout any suckers which were sufficiently large to eat the eggs of a trout at that season of the year, when the suckers tend to drop back into the deep holes in the streams. We did not, however, make our observations at night, which this work and others would show to be a very important point. It might be that the suckers would leave the deep holes and migrate to the beds at night.

MR. TITCOMB: I think the sucker is a very much maligned fish. I have not the slightest doubt that they will prey on the reefs at the time of spawning, the same as any other species in the lake. I have found them on the beds of wild trout; in fact we hatched two trout eggs that were removed from the stomach of a sucker, evidently having been swallowed without injury. The worst enemy of the brook trout on the spawning beds in the lakes is the brook trout itself. I once observed the spawning bed of brook trout where it reacehd from the shore away out into the lake. One pair of trout were operating under the shelter of a rook over which I could lean and watch them. With an ordinary stick about two feet long and a piece of line and a hook I caught seventeen trout, all of them apparently waiting for an opportunity to eat these eggs as they were expelled. This was a long time ago, but quite a large number of these trout do hang around the nests looking for spent fish. I think the females were all spent fish; there were some males. There is no more tendency on the part of the sucker to eat the eggs of the gray trout when they are spawning than there is on the part of the perch. You find also that the gray trout prefers the sucker to almost any other species in the lake when he is choosing his fish diet. I would rather have a three or four inch sucker as bait on a troll for gray trout than any other species I know of. So far as my observation goes the sucker is not interested in spawning wild trout in running streams in the fall of the year.

I want to bring out another point with reference to pike-perch—this is in Mr. Surber's territory in Minnesota. He will find suckers after

the pike-perch eggs, but he will also find that suckers spawning later than the pike-perch in waters of higher temperature than those in which the pike-perch spawn, will produce a termendous amount of progeny which the young pike-perch feed on. We have to be very careful in our study of this question not to upset the balance of nature. I have no doubt we should control the suckers in a lake such as the one Mr. Atkinson has reference to, but the varying conditions in different localities has to be taken into account.

CONTROLLING THE TROUT GILL WORM (*DISCOCOTYLE SALMONIS, SCHAFFER*)

JAMES LAIRD, *Oakdale, N. Y.*

G. C. EMBODY, *Ithaca, N. Y.*

This parasite is a small yellowish-white flat worm from one-eighth to one-fifth of an inch long, living on the gills of trout. It is easily seen with the naked eye after turning back the gill covers of an infested fish.

Elmer Schaffer in 1916 first described the species from specimens occurring on rainbow trout in the State Hatchery at Cold Springs Harbor, N. Y. At the present time it seems to be confined to Long Island waters. It is known to lay eggs, brown in color and shaped like tiny footballs which, with the aid of a microscope may be seen among the gill filaments. Apparently no one has determined how this worm is spread from one fish to another.

Fry and fingerlings are rarely if ever affected but yearlings and especially older trout may carry the parasites in such large numbers as to cause serious losses.

Plehn (1924) devotes a paragraph to this species but does not venture a special treatment for its control. However, in regard to the control of closely related worms, she mentions the use of a 2% solution of peroxide of hydrogen for ten minutes and a 1:8,000 acetic acid bath, 1 to 1½ hours. According to Davis (1929), European fish culturists also use a saturated solution of salt for 1 to 1½ minutes on closely related worms.

Laird (1927) successfully killed the parasites by spraying the gills with a solution of 1 part Zonite to 5 parts of water. It was necessary however, to treat the fish individually, a practice which would be impracticable in the case of a pondfull of infested fish.

In September, 1930, the writers working together in the hatchery of the South Side Sportsmen's Club of Long Island, tried out acetic acid, a saturated solution of salt, and a copper sulphate solution. The acetic acid treatment as Davis has stated, was found ineffective; the same was true of the copper sulphate bath. A saturated solution of salt was fatal to the worms when they were picked from the fish and placed in the bath but was ineffective when the fish were immersed in the solution. Apparently the reason for this was that the trout kept the gill covers tightly closed during immersion and the worms were probably not touched by the solution.

Experimentation with Zonite in various dilutions was attempted for the purpose of finding a solution harmless to trout after an immersion of 2 minutes. Dilutions from 1:256 to 1:640 were tried. The lethal dose was found to vary with the size and physiological condition of the fish as would be the natural expectation.

The strongest solutions generally harmless to brook trout of various sizes were as follows:

Length of fish	Zonite concentration	Period immersed
9 in.–12 in.	1 oz to 10 qts. water	2 min.
6 in.	1 " " 12 " "	2 "
4 in.	1 " " 13 " "	2 "
2 in.	1 " " 15 " "	2 "
1 in.	1 " " 15 " "	1 "

An attempt was then made to find out which of the above concentrations would kill the worms after a two minute immersion of the fish. In all trials the first two dilutions (1 oz.:10 qts. and 1 oz.:12 qts.) were found effective; the third (1 oz.:13 qts.) only partly so, while the fourth had very little effect upon the worms. In the last two the worms were apparently stunned but not killed. In the first two, however, plasmolysis set in very quickly causing distortion of the bodies.

Since the eggs are probably not harmed by this treatment, it is necessary to repeat the dipping process for the purpose of killing the young worms after hatching. The length of the incubation period is not known and hence the date of second and any subsequent treatments cannot be estimated. However, pending further study of the life history, one may tentatively suggest three treatments at intervals of 12 or 14 days.

Zonite is apparently a saline solution containing free chlorine. On exposure to the air, chlorine is given off. Hence it is necessary to use a fresh solution in the preparation of the bath.

Chlorine is known to attack living tissues and consequently extreme care must be exercised in treating fish. In measuring out the liquid a graduate of small diameter and about one ounce capacity with accurate graduations, is to be preferred. The ordinary 16-or 32-ounce, wide-mouthed graduate should be avoided.

The period of immersion should be measured with watch in hand and the length of this period should never exceed two minutes for the dilutions recommended.

A net or deep tray made of woven wire should be used in dipping the fish that they may be immersed and removed from the bath as speedily as possible.

If these precautions are taken, the losses from treatment should be confined to the very weak individuals.

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Discussion

MR. LAIRD: Zonite is very powerful stuff, and care is necessary in its use. One ounce of Zonite to ten quarts of water is very good for sterilization of hatchery ponds where it is desired to drain and clean them. If you cannot drain them dry, make up your mixture of Zonite and water, one ounce to ten quarts of water, and spray it around.

MR. TITCOMB: What area would that cover?

MR. LAIRD: A pond 200 feet long and 50 feet wide. The pot we use holds about two gallons. We make about four mixtures of that and go over the pond and clean it. It is good to clean the sides of your pond. One ounce of Zonite to ten quarts of water, then, is good for sterilization of ponds containing no water or where copper sulphate cannot be easily used; it is also good for dipping brushes, and tools used around the hatchery or around the pond. It is good for cleaning off the cement walls and troughs in the hatchery.

Just a word of warning as to the use of Zonite for dipping fish, especially the smaller size, for external parasites; fresh water must be immediately at hand to cleanse them as soon as they come out of the bath, and one minute is about all you dare to leave them in. I would use glacial acetic acid in preference to Zonite for any external parasites. Zonite is powerful and dangerous, but there is nothing better to cleanse anything that you have got to clean.

DR. DAVIS: Does Mr. Laird consider the treatment described in this paper superior to the spraying method described several years ago?

MR. LAIRD: What Dr. Embdoy and I were after was something easier to use and would take less time than the spraying method, which

meant two days work for a thousand fish. We wanted to get a solution that would kill the worm without going to all that trouble, and we found that that ratio of one to ten or one to five would do the work.

MR. TITCOMB: I would like to amplify what Mr. Laird said about the use of Zonite for disinfecting brushes used around the hatcheries. I do not believe we are sufficiently careful in the use of our utensils. It is very easy to transfer disease from one trough to another or from one pool to another by using the same brushes or tools. We find our employees, even our old hands, get very careless about it in passing from one trough to another in the hatchery, thus making possible the carrying of disease. Zonite seems to be a very good material for conveniently and quickly disinfecting the brushes.

FURUNCULOSIS INVESTIGATIONS

MARGARET L. STEVENS AND W. M. KEIL

Tuxedo Park, N. Y.

Covering a period of more than thirty-three years of fishery work, the senior author (Keil) has on many occasions been brought in close personal touch with serious outbreaks of the fish disease we have come to regard as furunculosis. While it is only within comparatively recent years that any attempt has been made in this country to confirm the identification of the causative organism of these epidemics, it is certain that this or some other closely related blood infection has been taking a tremendous toll of trout and salmon from our fish cultural establishments throughout America. It is doubtful if there exist to-day many hatcheries or rearing stations that are entirely free from at least sporadic outbreaks of this or similar diseases.

In the course of our investigating many epidemics in both wild and domesticated fish there has been brought to light so much contradictory evidence that we have come to believe that in a certain proportion of such outbreaks of supposedly furunculosis, we may be dealing with other bacterial organisms which manifest themselves in almost identical bacteriological and pathological characteristics.

During the past two years we have been attempting to eradicate from the Tuxedo Fishery a disease that has been positively identified as true furunculosis (Bacillus salmonicida) described by a number of investigators in Europe and by Davis, Belding and Marsh in America. This outbreak of the disease at Tuxedo was in its earlier stages so totally unlike what is generally regarded as the symptoms of furunculosis, that at first it was thought to be caused by some unrecognized external parasite. Later investigations revealed it as a blood infection of bacterial origin, but again confusion arose when the original culture taken from hearts blood and from liver and kidney gave us a bacillus with no morphological resemblance to the organisms usually found in furunculosis examinations.

The disease made its first appearance late in October among two year old brook trout that had been sorted out preparatory to spawning operations. It will be well to note that previous to this time no unusual mortality had occurred among these fish either in the fingerling, yearling or two year old stages. It is also noteworthy that the water temperature which had

been maintained at around 55 degrees throughout the summer months had fallen at this date to 45.

Without the usual preliminary warning, shown by an occasional dead fish against the screen, or by an apparent change in coloration, actions or appetite, a large number of male fish suddenly developed great areas of irregularly shaped, grayish lesions over their sides and backs. The appearance was so characteristic of external parasitic infections, that although no large number of recognized parasites could be found on the body, gills or fins, they were on general principle given the "old cure all," a salt bath. However, none of the remedial dipping solutions were of value. In fact any attempt to check the progress of the trouble by solutions of salt, potassium permanganate, acetic acid, copper sulphate, etc., increased the mortality and the rapidity with which the external lesions developed. The progress of the disease was so rapid, especially among the male fish, that perfectly normal appearing specimens in the afternoon would be almost completely covered with the infected areas and would be found dead or in dying condition by the following morning.

The general appearance of these diseased tissues bore such a marked resemblance to the description given by Dr. Davis of fishes infected with *Bacillus columnaris* that every effort was made to discover if this bacterium was present, but without success. These areas were as previously stated irregularly shaped and characterized by a general reddening under the mucus, the outer edges of which showed punctate hemorrhages. It can be best described as not unlike a ground fire spreading through short, dry grass, the burnt over portions dead or smoldering, and the advancing front line still aflame.

We could believe that this condition was the outward manifestation of furunculosis alone, but nothing except the associated filaments of Saprolegnia could be found by the most painstaking microscopical examinations. At this stage the visceral cavity contained more or less fluid of a decided reddish color, although none of the internal organs were broken down or visibly congested. It was unfortunate that bacteriological facilities were not readily available at this particular time, although cultures from the skin surfaces would not have been of especial value due to contamination. However, in about ten days time the first typical boil-like lesion was found, and from that time on the usual symptoms of chronic furunculosis were in evidence.

The peak of the mortality was reached with the water temperature standing at 41 degrees, but with the disease at-

taining a more chronic-like character, there was a noticeable decrease in the number of fish developing the fungus-like skin lesions. The disease ran its course in about six weeks with a loss of almost seventy-five per cent of the affected lot. Steelhead and brown trout of various ages were not affected although at times held in water flowing from the diseased fish. An occasional yearling brook trout did die during the winter and following spring with pronounced furunculosis lesions.

No eggs had been taken from the two year old trout, but the necessary supply was obtained from a source known to be free from all signs of furunculosis. During the next summer however there was a typical outbreak of the disease among the fingerlings resulting from these eggs, although they were held in pools thoroughly disinfected and removed from any possible contact with carriers or contaminated boots, brushes or other hatchery utensils. Cultures from the hearts blood of these fish gave us the same short bacilus ordinarily found in furunculosis investigations, and the cultural reactions agreed with previous findings.

Preparations were made during the summer to have everything in readiness to carry out exhaustive bacteriological examinations should the trouble recur among the older trout with the approach of the spawning season. As before, it made its appearance with the ripening of the two and three year old brook trout, and again the first manifestations were the external lesions with the associated hyperemia and fungus-like film. Direct smears from such diseased areas showed a variety of bacteria, none of which were thought to be in sufficient abundance to have caused this condition. However there was one bacillus that appeared unusual, and when we also found this same organism in smears taken direct from hearts blood, it was thought that a new or at least an undescribed bacterium had been discovered.

The same bacillus, although slightly changed in morphology, was obtained in pure culture from the hearts blood and liver. This bacillus was from 5 to 8 micra in length and 0.8 to 1.1 in width. The ends were rounded and there was a tendency in many of the bacilli to taper slightly towards both ends. It was non-motile and Gram-negative. In the exact center of many of the bacilli was a very pronounced unstained oval area that had every appearance of being a spore, and was so regarded by a number of trained observers who examined the direct smears and earlier cultures from hearts blood and from the bloody serum of unbroken muscular lesions.

Such organisms survived incubation at 37 C. but were killed at 57 C. Upon transplanting and in the older cultures, the morphological appearances were changed and many shorter, typical furunculosis bacilli were present together with the longer forms now showing pair formation and bi-polar staining. As Miss Stevens' description of the cultural characteristics will show, in all later transplants the organism had apparently degenerated into the usual forms encountered in investigations of furunculosis. Transplanted cultures were forwarded to Dr. D. L. Belding and also to Mrs. Isobel Blake (Williamson) who is conducting the furunculosis research work for the Fishery Board of Scotland. Both pronounced them pure cultures of *Bacillus salmonicida*. Mrs. Blake reporting also that they were serologically identical (Complement fixation test) with strains from Scotland, France, Germany and Austria.

The purpose of this paper is to bring to the attention of investigators and fish cultural workers the probability that under particularly favorable conditions the pleomorphic organism will acquire a non-typical form, giving the impression of spore formation, and at the same time be of such a virulent type as to result in such rapid destruction of skin surfaces as to develop capillary hemorrhages. To our knowledge seldom has any outbreak of furunculosis been investigated by trained observers in the earlier stages of its development, and it is the hope of the writers that those who have the opportunity and facilities to do so will concentrate their attention on this phase of research.

Fish culturists will find their local physicians or hospital laboratory technicians will gladly assist them in at least securing uncontaminated direct smears from the bloody serum of unbroken surface lesions or from the intestinal cavity, and we would greatly appreciate such slides being forwarded to us for comparison. The writers will also welcome communications from fish culturists who may have observed similar skin lesions in the earlier stages of what later proved to be furunculosis.

In the following pages, Miss Stevens, Technician of the Tuxedo Laboratory, gives the morphology and cultural characters of the organism. You will note that her examinations were not conducted until the disease had progressed to the stage where external furuncles were in evidence. At any rate her contribution should be an invaluable record for our fish cultural members who may have occasion to consult with their local physicians or hospitals.

Cultural Characteristics

These examinations were performed November 5th, 1930 and December 29th, 1930 with identical results. In making the bacteriological examinations of the diseased trout specimens having abscesses were selected. Under asceptic conditions the hearts blood and livers were cultured. Also cultures were made from the bloody serum of the skin abscesses. The same organism in pure culture was obtained in each case. The isolated organism was rod-shaped, having a tendency toward pair formation. The ends were rounded and showed bi-polar staining especially upon culturing. It was non-motile and Gram-negative. Cultures were grown at room temperature, control tubes being used in each case.

Agar Plate—Small transparent colonies appeared in 24 hours. A slight brown pigment appeared on the second day which increased until the entire medium was colored brown. The colonies increased in size, were circular, raised, moist and brown.

Agar Slant—On the second day the stroke line of growth appeared slightly pigmented. After the third day the medium assumed the pigment.

Blood Agar—A rich growth appeared in 24 hours. There was no hemolysis after fourteen days.

Loeffler's Blood Serum—Rich growth appeared in 24 hours. The pigment did not appear until the sixth day. After the seventh day there was a gradual liquification. The entire medium was liquified and pigmented after 14 days.

Gelatin Stab—After 48 hours the upper part of the medium was liquified. The growth was flocculent, produced a slight brown pigment near the surface after the third day and complete liquification after the fourth day.

Bouillon—A diffuse growth occurred after 24 hours which became profuse and produced pigment after the 3rd day. The culture was contained in a small flask.

Litmus Milk—Was neither acidified nor coagulated.

Potato—Produced a slight growth after 48 hours and pigment after the 3rd day. At no time was the growth profuse.

Sugar reactions—No pigment was produced.
Lactose—No acid or gas was produced.
Glucose—Acid but no gas after 24 hours. Acid and gas after 48 hours.
Saccharose—Faint acid. No gas after 24 hours. Faint acid and gas after 48 hours.
Mannite—No acid or gas after 24 hours. Faint acid, no gas after 48 hours. Gas was produced after the 4th day.

Gas production was greater in glucose than in manite or saccharose.

On July 8th, 1931 tubes were again set up using a transplant of the original culture obtained from the diseased trout on December 29th, 1930. These cultures run for 14 days under the same conditions as before. The fermentation reaction was also tested with maltose. At this time the organism had assumed more of a cocoid appearance, did not produce indol, and had fewer forms showing the bi-polar staining. The growth and reactions were essentially the same as previously run with the exception of the sugar reactions. Glucose, maltose and mannite formed acid and gas; maltose and mannite producing more gas than glucose. Saccharose and lactose formed neither acid nor gas.

Discussion

DR. DAVIS: Mr. Keil wrote to me regarding this paper, I suppose because I had had some correspondence with him regarding the outbreak of furunculosis at the time, but in spite of his urgent invitation to do so, I was unable to visit Tuxedo and therefore have no personal knowledge of the conditions. I hesitate to believe that an organism which had been studied so closely and so extensively as *Bacillus salmonicida*, which, as you know, has probably received more attention than any other organism producing disease in fish, could occur in spoliating form without having been noted by some previous observer. The symptoms which he described at the early stage of the outbreak are certainly not characteristic of furunculosis, and my suggestion by way of possible explanation is that he was dealing with a secondary infection. No doubt he had true furunculosis, but a secondary infection in a case of this kind is nothing extraordinary. That is the most probable explanation of the cause of the symptoms and other characteristics which he found in this case and which do not occur in typical furunculosis.

FISHERY RESEARCH BY THE OHIO DIVISION OF CONSERVATION

E. L. WICKLIFF, CHIEF

Bureau of Scientific Research, Ohio Division of Conservation

The Bureau of Scientific Research is one of the eight bureaus in the State Division of Conservation, of the Department of Agriculture. The object of the bureau is to investigate practical wild life problems in order to determine facts essential for intelligent wild life conservation. The major projects are:

I. *Fish Survey of the State*: This work was started in 1920. To date we have made collections in more than 1,500 localities representing the 88 counties of the state, and have listed 163 species and varieties of fishes for Ohio. Distribution maps have been completed and the environmental factors involved in distribution are being determined. These data are essential for successful stocking. As an example, largemouth black bass and yellow perch have been stocked by the thousands in our creeks and rivers and yet these species at the present time are rare in the streams of Ohio.

Food habits, life histories, habitats, age, rate of growth, time of spawning, parasites and diseases, body measurements, polluted waters, stocking problems, methods of propagation and economic importance are all being studied. These data, when complete, should result in a definite fish conservation policy for Ohio, and in a revision of Dr. R. C. Osburn's book, "The Fishes of Ohio."

Through the courtesy of the Illinois State Natural History Survey we have obtained 5,000 copies of each of 55 species in natural colors. We also have 21 paintings of our native Ohio fishes.

II. *Hydrobiological Survey of the Western End of Lake Erie*: This project is part of a complete cooperative survey of Lake Erie. From the standpoint of the Ohio Division of Conservation the object is to determine the suitability of the lake for fish life because of the reported decrease in catch.

During the month of August, 1926 the Ohio Division had five biologists in the field; in the fall of 1927 we had two; in 1928, three from May to November; in 1929, sixteen during the summer; and in 1930, six summer biologists. The United States Bureau of Fisheries furnished a limnologist in 1929 and 1930. In 1928 a series of collecting stations were estab-

lished and visited at regular intervals. These were continued in 1929 and 1930.

Quantitative counts were made of samples of plankton (microscopic plant life and crustaceans) taken at different water levels. Quantitative counts were also made of bottom organisms. These determinations are indicative of the productiveness of the lake. The chemistry of the water was also determined and some work was done on the bacteria of the lake. Larval and post larval fish were collected with meter nets and young fish were obtained with a 100 ft. seine, Peterson trawl, and Helgoland trawl. Food studies were made of 24 species, and 71 species were examined for parasites.

While the reports of the various investigators will be published in the near future by the United States Bureau of Fisheries, the following conclusions may be drawn:

1. That pollution in the open waters of the lake is not such an important factor in depletion as was first supposed. That pollution sufficient to kill fish food, fish eggs, young and adult fish, does exist at the mouths of several streams emptying into Lake Erie and in certain inclosed bays.
2. The production of fish food in the form of phytoplankton, zooplankton, bottom organisms and forage fish, is sufficient to support a greater number of commercial and game fish than are now found in the lake. Quantitative fish food studies, both vertical and horizontal, and the healthy condition of the fish examined, support this statement.
3. The parasite study, to date, shows that parasites and diseases are not important factors in the depletion of commercial species, as no serious disease, epidemic in nature, was found, and such fish in the past have not been reported to us by the commercial fishermen.
4. More species and a greater number of specimens of larval, post larval, and young fish, were collected in meter nets and the Peterson trawl near the main shore where pollution was suspected, than in the open waters of the lake.
5. More species and a greater number of specimens of young and adult fish from one inch to two feet in length were collected in a 100 ft. seine along the main shore where pollution was suspected than around the islands in the open lake.

The publications resulting from this survey will be as follows:

1. Limnology of Lake Erie, which will include an introduction, physical hydrography, sediments, chemistry, bacteriology, phytoplankton, zooplankton, qualitative plankton studies, bottom organisms, residues and general review.
2. Distribution and natural history of young fish in the western end of Lake Erie.
3. Parasites of fishes in Lake Erie.
4. Food of fishes in Lake Erie.

III. *In 1930 at Buckeye Lake a Similar Investigation was Conducted*: This lake is eight miles long, averages about one-half mile in width and is located in central Ohio. The survey included quantitative counts of phytoplankton, zooplankton and bottom organisms, and chemical analysis of the water.

A fyke net caught over 5,000 adult fish and of this number 4,000 were tagged. A 50 ft. seine was used to catch young fish along shore. These fish were utilized in making parasite and disease studies, food analysis, growth determinations, abundance of species and length group frequencies.

IV. *Fish Parasites by R. V. Bangham, Wooster College, Wooster, Ohio*: "The studies on parasites of fresh water fishes in Ohio started in 1920 and have been continued to the present time. The first studies on parasites of the large and small-mouth black bass were a part of my Ph. D. thesis which was completed in 1923. These findings included the listing of seventeen species of parasites, two of which were described as new forms. The life cycle of the small bass cestode, Proteocephalus pearsei, was worked out. The entomostracea Cyclops prasinus and Eurycercus lamellatus, were reported as intermediate hosts.

"These life history studies were continued for the Ohio Division of Conservation, and the cycle of the large bass cestode, Proteocephalus ambloplitis, worked out. The first intermediate hosts being Epischura lacustris and Hyllella knickerbockeri, with second intermediate hosts young fish of a number of species such as young black bass, yellow perch, rock bass, fresh water dogfish and shiner minnows. It is in this stage where the larval form does its chief damage to the black bass as it encysts in the reproductive organs and viscera forming adhesions and sometimes rendering the host sterile. The adult stage is in lake bass and fresh water dogfish.

"The ecological distribution of several species of fish parasites was studied. The bass parasite just referred to above, P. ambloplitis. was found only in lake black bass both in the Ohio and Lake Erie drainage systems, while P. fluviatilis was confined to stream bass. Certain large ascaris nematodes were only found in black bass from the Ohio River drainage. The large encysted larval fluke, Clinostomum marginatum, was found in very localized areas, both in lake and stream drainage. Many other cases of similar nature show the need for a more complete knowledge of life history studies of these forms.

"Studies were made of parasitism of hatchery fish with special reference to ectoparasites which often cause great loss

of young fish. These included the control and treatment for such forms as Ichthyophthirius multifiliis, Gyrodactylus sp., Ancyrocephalus sp., Chilodon sp., and Cyclochaeta sp. Parasites of bait fish and of minnows used as food for young hatchery fish were determined.

"It was found that by proper feeding methods young bass could be reared practically free from parasites, and that they were much superior as breeders to those formerly obtained from Lake Erie.

"A large portion of the time was given to studies of parasitism of fish from the western portion of Lake Erie. These data which are soon to be published include the examination of 1,280 fish belonging to 71 species. Approximately 85 species of parasites were found in these fish. Three new species of flukes and three new cestodes are to described. These data will be combined with the studies of Dr. George W. Hunter, III, who examined about 900 fish of the same species from the eastern end of Lake Erie. Comparisons will be made regarding the degree of infestation of these fish and the economic importance of the parasitic infestation to Lake Erie fish.

"As a part of the Buckeye Lake survey of 1930, parasite studies were made of 500 fish belonging to 38 species. Of these 157 or 31% were free from all parasites. The others carried parasites belonging to 25 different species. When species of fish examined here are compared with the same species from Ohio streams or from Lake Erie the number of species of parasites found infesting Buckeye Lake fish was quite low. In a few cases there was heavy infestation, such as the large number of parasitic copepods on gills of several species of fish, and the large numbers of cysts of a sporozoan in the viscera of young gizzard shad. This last form often caused heavy mortality the first season."

V. *Stream Pollution Studies*:

1. A preliminary study of the Miami River at Dayton, Ohio, was made during the summers of 1929 and 1930, by Mr. C. A. Barker of Dayton, Ohio. "This was previous to the installation of the Imhoff Disposal Plant to take care of the domestic sewage. In this study a check was made of the river below Dayton as far as the West Carrollton Dam and above the city two stations were established on each of the four contributing streams, Mad River, Miami River, Stillwater and Wolf Creek. An attempt was made to check all the living things both plant and animal, also to record tem-

perature, turbidity and potential hydrogen ions. With so many factors involved the check was found to be very unsatisfactory. For no apparent reason the phytoplankton varied from the same station from time to time and even such sensitive fish as the black bass were found in heavily polluted water.

"To determine the progress in recovery some factor must be chosen that will be content and also indicative of the worst condition during a given period.

"A study of the Miami River from Dayton down stream made evident the fact that the domestic sewage of the city was not the only source of pollution. The paper mills and other industrial plants along the river use the stream as a dumping place for all sorts of wastes. Another factor playing a very important part in stream conditions is the dams. As the water flows over these dams its oxygen content is raised and the fauna below the dam show a group much less tolerant to a low oxygen content than that immediately above the dam. Especially during the extreme low water of 1930, have these industrial dams figured in the stream life. The water diverted to the mills by the dams left very little to flow on in the usual channel. Sewage and wastes added during this extreme low stage brought appalling results.

"The animals most significant of the septic and recovery areas seem to be first of all the Tubificidae; second, the Musculium; next, the Hirudinea. If the Chironomidae could be identified to species they might also form a good index. No other insect larvae appear in the polluted area, other larvae disappear with the entrance of the first sewage. The Ancylidae above the pollution may not be the F. fusca appearing farther down stream. The other Mollusca are surface breathers and their abundance indicates only the presence of food and an absence of enemies.

"The dams are successful barriers for some forms of stream fauna. They, with the polluted areas divide the stream into a series of Ecological groups. The determining factors appear to be dissolved oxygen, food and enemies. Wherever there is oxygen enough for fish life the Tubificidae disappear."

The following two papers are abstracts taken from the Ohio Journal of Science. of a limnological survey of the Hocking River during the fall, winter and spring of 1930-1931, and were made under the general supervision of Dr. F. H. Krecker, Head of the Biology Department at Ohio University, and in cooperation with the Ohio Division of Conservation.

2. The plankton of the Hocking River by Lee S. Roach: "The Hocking is a swift river traversing a rapidly eroding

clay region. The plankton is rather uniformly distributed throughout the length of the river. During the autumn copepods were the dominant zooplanktonts. The winter dominants were rotifers. Diatoms were the dominant phytoplanktonts, blue-green algae the least abundant and green algae intermediate. Single celled animals were fairly numerous, decreasing in the main with an increase in zooplankton, especially copepods and rotifers. Of the factors studied, light, acidity, current, chemical contents of the water and temperature, only the latter two showed variation that corresponds with changes in plankton. Temperature range from October to March was 13 degrees centigrade to 1 degree centigrade. Plankton abundance varied directly with temperature. All phytoplankton varied directly in the same relative proportion. Of the zooplankton, cladocerans are apparently the warm water dominants, while rotifers are the cold water dominants. Copepods were the dominant medium temperature forms. Zooplankton as a whole, however, decreases and increases directly with the temperature.

"The chemical condition studies varied so little at the majority of the stations that no correlation with plankton could be made. However, at three stations below the city of Lancaster the river was undeniably polluted with domestic sewage, (as indicated by increased free and albuminoid ammonia, nitrates and nitrites and decreased oxygen) and there was a direct correlation with plankton. On the whole, total plankton decreases with pollution increase. However, blue-green algae increased directly with pollution, as did the single celled animals. Rotifers increased with a certain degree of pollution, but diminished with septic conditions."

3. The bottom invertebrates of the Hocking, by William B. Ludwig: "The Hocking is interesting limnologically because it is chemically affected by domestic sewage, mine, oil-well, and factory wastes.

"Forty-seven forms were taken, thirty-five of these being classified to genus and twelve to family only. Chironomidae and Trichoptera were the most cosmopolitan groups, the latter being uniformly less abundant. The most striking feature concerning the distribution of the other forms was the great abundance of a characteristic type at one or two stations and its scarcity or absence at all others. At two consecutive stations, having domestic pollution, there were 295,000 and 96,000 Tubificidae respectively per square meter; at another station there were 900 Ancylus; at a third 16,338 Goniobasis;

and at still another 1,624 of the isopod, Assellus, some amphipods, and 200 leeches.

"Oxygen, and nitrogen mainly as albuminoid and free ammonia, were important chemical factors affecting distribution. These factors indicated pollution due to domestic sewage. The PH extremes occurring at different parts of the river were 6.8-7.7. The other important factor correlated with distribution was the substratum. Chironomidae and Trichoptera were most abundant where there was algae or solid substratum. The Tubificids depended upon soft, mucky substratum. Goniobasis was most abundant on solid rock. The crustacea and leeches were recovery forms living most abundant where the polluted conditions had improved considerably. May-fly and dragon-fly nmyphs and the snail, Ancylus, were present only where there was no indication of pollution. Chironomidae and Trichoptera became most abundant in these situations."

VI. *Experiments in Fertilizing Whitefish Eggs and Fertility Tests of Whitefish Eggs Received from Commercial Fishermen*: Since the fall of 1925 I have been conducting experimental work at our Put-in-Bay hatchery in order to improve the technique of fertilizing whitefish eggs. 237 experiments were made and these may be summarized as follows:

1. To obtain the highest percentage of fertile eggs the water temperature should be below 60° F. At 53° F. a normal fertility was obtained.
2. Milt allowed to remain in water as long as 10 seconds before using, fertilized from 85 to 100% of the eggs. If the milt remained in water for one minute the fertility was reduced to 74%; two minutes, 27%; and three minutes, 9%.
3. Milt, if kept dry and at a temperature of 44° F., showed a fertility of 95% at the end of five hours.
4. Ripe eggs allowed to remain in water at 44° F. for three and a half minutes were 90% fertile when fresh milt was used to fertilize them; in seven minutes their fertility was reduced to 12% and in fifteen to only 1%.
5. A teaspoonful of milt is capable of fertilizing up to one million eggs and give a fertility of 93%.

In 1929 the following spawn directions were printed on cards for commercial fishermen. They read as follows:

First, Take only fresh, RIPE eggs in a DRY spawn pan.

Second, Add fresh milt (jack) to the DRY eggs in the DRY pan.

Third, Add sufficient cold, fresh lake water, with dipper, to completely cover the eggs and IMMEDIATELY gently stir (from several to fifty seconds) the eggs and milt with the clean hand.

Fourth, Allow the mixture to stand for several (two to ten) minutes and then wash off the milted water with cold fresh lake water.

Fifth, Carefully place the fertilized eggs (after each spawn taking operation) in a spawn keg, half filled with cold fresh lake water, and stir occasionally. Use another keg as soon as the first one is one-fourth filled with eggs.

Sixth, Keep the water in the keg COLD.

The explanation for the above directions is as follows:

First, Fresh, ripe whitefish eggs will flow from the fish in a steady stream, with slight pressure by the hand, and WITHOUT FORCING THEM.

Second, Both milt and eggs must be taken dry if a HIGH percentage of fertile eggs is desired. One teaspoonful of milt properly handled will fertilize EIGHT QUARTS of fresh ripe eggs and give a fertility of ninety per cent.

Third, Cold, fresh lake water MUST be added to the mixture of dry eggs and milt in order to FERTILIZE the eggs. Water stimulates the fertilizing bodies in the milt and assists their union with eggs. Milt in water longer than ONE MINUTE is practically worthless, as the wriggling microscopic fertilizing bodies in it lose their fertilizing power very rapdly. Eggs also lose their ability to be fertilized if allowed to remain in water longer than several minutes. Stirring insures a complete mixture of water, milt and eggs, which is necessary to obtain a high percentage of eyed eggs.

Fourth, After the eggs have remained in cold, fresh lake water for several minutes, they absorb some of it. The resulting water bag around the egg serves as a buffer and tends to protect the egg from injuries.

Fifth, Too many eggs should not be placed in a keg, as their volume doubles in from twenty-four to thirty-six hours, due to the gradual absorption of water. Too many eggs may result in their death from a lack of oxygen. Crowding also distorts the shape of the eggs. Stirring prevents sticking.

Sixth, The eggs in the kegs should be kept cold as warm water kills them.

6. During the fall of 1929 one spawn taker handed in 283 quarts of whitefish eggs. They averaged 93 2/10% fertile. Another handed in 214 quarts of eggs and they averaged 90 4/10% fertile. Eggs received from 12 of our best spawn takers totaled 73,400,000 and averaged 87 2/10% fertile. In 1930 the eggs received from November 8 to 14 and from November 21 to 26 averaged 71 7/10% fertile, while those received from November 15 to 21 averaged only 25% fertile. High air and water temperatures will explain the low fertility.

Discussion

DR. EMMELINE MOORE: What appropriation are you working on?

MR. WICKLIFF: At the present time the appropriation has been reduced to just a few thousand dollars, therefore our activities have been curtailed to a certain extent. In 1927, 1928, 1929 and 1930 the appropriations were sufficient to carry on the work.

DR. EMMELINE MOORE: With the curtailed appropriation where will your emphasis lie?

MR. WICKLIFF: At the present time we are trying to compile the data we have on hand. That is about as much as we can do.

PRESIDENT LECOMPTE: You made a statement with regard to tagging fish. Is that for the purpose of determining their migration?

MR. WICKLIFF: Yes, local movement and seasonal migrations, also the rate of growth and their life history.

PRESIDENT LECOMPTE: What species did you tag?

MR. WICKLIFF: We tagged twelve different species, primarily the game and food fishes of the state.

PRESIDENT LECOMPTE: When did you start this work?

MR. WICKLIFF: Last year.

PRESIDENT LECOMPTE: Have you any statistical information showing the results?

MR. WICKLIFF: Yes, we have a few returns to date, but that is not a cross section of the total number of fish tagged. We have returns on white crappie, bluegill, channel catfish and marble catfish; also white bass. The white bass appears to be more migratory than the other species. White bass tagged at one end of the lake were taken after several weeks at the other end. Our net was placed at one end of the lake at one time and a month later at the other end, and quite a number of white bass that were tagged at the one end were taken a month later at the other end. It is not true of the other species. The lake is eight miles in length.

PRESIDENT LECOMPTE: You have not tagged in open waters where they could gain access to the Mississippi and then on to the coast?

MR. WICKLIFF: Yes, we have done a small amount of tagging on the Miami, which runs into the Ohio river and thence into the Mississippi; the Maumee, which runs into Lake Erie, and the Scioto, which runs into the Ohio river, but we have not received returns.

PRESIDENT LECOMPTE: General Pearson, of the United States Bureau of Fisheries, who is carrying on an experiment with the striped bass, or what is known as the rockfish of Chesapeake bay, has been tagging these fish at Annapolis, which is just below Baltimore, at the mouth of the Severn river. A fourteen inch rock weighing a pound and a quarter was tagged off Hawkins point at Annapolis on July 2nd, and within less than forty-eight hours that fish was caught thirty-two miles north of the point at which it was tagged. About the 14th or 15th of September a gentleman brought in a tag and asked me if I could give him some information as to where it came from. It was taken from a fish shipped by commercial fishermen from Rock Hall, Maryland, to a wholesale dealer in the markets of Baltimore. I forwarded the tag to Dr. Pearson. This particular fish was tagged on the 7th of July with 299 others at Annapolis and was caught at Rock Hall within a distance of forty miles from the point at which it had been tagged. The tags returned indicate that the rockfish are working north towards the head of the bay. No returns have been received to indicate that the fish have been taken below the point at which they were tagged. It is very important, I think, to ascertain the migration routes and the distances that these fish do migrate.

NOTES ON THE FOOD AND PARASITES OF THE MOSQUITO FISH (*GAMBUSIA HOLBROOKI*) IN FLORIDA

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The subject of the destruction of mosquitoes is one of general interest. Various methods of eradicating these insects have been devised, their success, apparently, depending more or less upon the locality in which they are used. Communities having lakes, ponds, or irrigation ditches near at hand may find relief from the mosquito plague by introducing certain top minnows into quiet waters of this kind, these small fish being able to keep the surface of the water comparatively free from mosquito eggs and wigglers.

During the past summer, the writer has had an opportunity of making a study of some mosquito fish from a lake in Florida. The locality in question is reported to be unusually free from mosquitoes throughout the year.

Specimens of the Florida fishes, sent for determination to Mr. Lewis Radcliffe, of the U. S. Bureau of Fisheries, were identified as *Gambusia holbrooki.*

The genus *Gambusia,* established in 1854 by Poey, belongs to the family Poecilidae and the order Cyprinodontes, according to Jordan (1923). The generic name was given from the fact that in Cuba such little fish are called "gambusinos." As far as is known, all species of *Gambusia* are equally efficient as "mosquito killers."

Gambusia holbrooki is found in lowland streams, swamps, and rice ditches of the South Atlantic States, ranging from Florida to New Jersey. It is not uncommon in suitable areas in Chesapeake Bay as far north as Annapolis, Maryland.

Gambusia was introduced from the United States into Spain and from there into nearly all other countries of Southern Europe (Hildebrand, 1931), also into Palestine, the Philippine Islands, the Hawaiian Islands, the Argentine, and the West Indies. Those familiar with life in the Hawaiian Islands before 1904 and at the present time are willing to give Gambusia the credit for at least greatly reducing the mosquito population there. Hildebrand says that the results claimed for *Gambusia* in Southern Europe and especially in Italy, as an eradicator of mosquito larvae, far exceed those secured in the United States; however, from his own figures,

based on experiments extending over four breeding seasons, he shows conclusively that *Gambusia* greatly reduces mosquito breeding. For instance, reductions brought about by the fish, as shown by the data, are 57.8% for Anophelines and 80.8% for Culicines.

According to reports given by Smith (1912), Kuntz (1914), and Hildebrand (1919, 1921), *Gambusia* reproduces very rapidly. Being viviparous the eggs are fertilized and hatched within the body of the mother. The young are 8 to 10 mm. in length when born. One female in a single season may produce many broods, or in the neighborhood of 345 offspring. The number of fish in one brood may vary from 33 to 211. Hildebrand examined 2,593 fish and has shown quite conclusively that in immature *Gambusia* the sexes are evenly represented; but the males soon become less numerous, the greatest scarcity occurring in midsummer.

Seal (1910) advocated the use of *Gambusia* as a destroyer of Anopheles, describing these fish as "foragers always on the move in search for food, skimming over the tops of plants with restless energy" and declaring that they will find their way to the remotest possible breeding places of the mosquito.

The plan of combatting mosquitoes by the introduction of such species as *Gambusia* into natural and artificial waters, as ponds and garden pools, has been tried with success in New Jersey, according to Kuntz (1914). He thought this species had an important economic worth, since it feeds largely on insects and insect larvae, especially mosquito larvae.

An article entitled: "Fishes in relation to mosquito control in ponds," was published by Hildebrand (1919) who pointed out that Gambusia was selected for experiment for the reason that it is adapted to procuring its food at the surface of the water; also that it is able to live under a great variety of conditions and especially in water suitable for the support of mosquito larvae, and because it is known to be very prolific. One adult female was observed that ate 165 large larvae in less than 12 hours. This author's opinion is that mosquito breeding, if not entirely eliminated, is at least greatly reduced by the top minnow.

In discussing the feeding habits of *Gambusia,* Hildebrand (1921) states that while the fish shows a distinct preference for live bait, insects and insect larvae constituting a large part of its food, the majority of the stomachs examined contained some "plant tissue consisting mostly of algae", the comparatively large amount found in several specimens, pre-

cluding the probability that this was taken by accident in the capture of animal prey.

The present writer is especially interested in the food of fishes and has made a study of the organisms found in the digestive tracts of the Florida top minnows.

In July 1931 seventy top minnows were collected from Lake Auroro, at Hesperides, near Lake Wales, Polk County, Florida. This is a small freshwater lake about three quarters of a mile wide and a mile and a quarter long. The water is exteremely clear and free from growth of higher plants and even filamentous green algae are difficult to find. Probably on account of the extreme clearness of the water, the large fish remain in the depths and will rarely allow themselves to be caught. Around the edges of the lake, however, there are always to be seen numerous schools of top minnows. Although very active in their movements, these little fish are caught in a dip net without much difficulty. The fish are light greenish brown in color when alive, but in the specimens preserved in formaline the color fades to silver.

The method followed in the laboratory was first to remove the entire digestive system from the fish and place it in a drop of water on a glass slide. The contents were then carefully scraped out and a coverglass added. Drop by drop glycerine was allowed to run under the edge of the coverglass and gradually replace the water. The food organisms were then systematically identified, counted and tabulated. The results were embodied in the accompanying table.

The seventy specimens of *Gambusia* studied ranged in length from 12 to 32 millimeters. Thirty-five of the fish measured between 20 to 25 millimeters. The five largest fish ranged from 28 to 32 millimeters in length. The measurements are considerably less than those given by Hildebrand and Jordan.

It was found that the fishes measuring from 12 to 27 mm. in length contained on an average 18 specimens each of the alga *Peridinium*. and six desmids. In addition there was found in each of the digestive tracts an appreciable amount of such filamentous green algae as *Zygnema, Oedogonium, Bulbochaete,* and the like. In only four instances was a blue-green alga present, a species of *Scytonema*.

The fish in a second group, measuring 21 to 26 mm., fed to a lesser extent on the above organisms, but contained more larvae and adult insects. In neither group were Rotifers important.

Number of Individuals	3	4	4	3	2	2	5	9	2	6	9	4	4	4	4	1	1	1	1	1	Total	Average
Length in mm	12	13	14	15	16	17	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
ALGAE																						
Scytonema	....	....	....	....	....	....	....	....	....	....	....	....	x	....	....	....	....	x	....	xx	....	....
Peridinium	73	327	79	65	48	36	170	219	3	121	12	8	....	36	4	....	....	....	....	....	1201	17.1
Desminds (totals)	15	16	20	8	8	9	15	14	13	91	26	47	46	6	1	....	8	4	....	4	401	5.7
Desmidium	....	....	....	....	....	....	....	....	....	4	....	....	....	....	....	....	....	....	....	....	4	....
Micrasterias sp. (total)	10	6	9	1	3	5	8	10	7	46	19	26	73	5	1	....	....	....	....	....	239	3.4
Pleurotaenium	....	....	....	....	....	....	2	1	2	1	1	....	....	1	....	....	....	....	....	....	8	0.1
Staurastrum	5	6	3	3	2	1	1	....	1	9	2	8	2	....	....	....	6	3	....	....	52	0.7
Cosmarium	....	2	4	2	2	1	....	....	....	3	....	1	....	....	....	....	1	....	....	3	19	0.2
Xanthidium	....	1	4	1	1	2	4	2	3	27	4	12	21	....	....	....	1	1	....	1	85	1.2
Euastrum	....	1	....	1	....	....	....	1	....	1	....	....	....	....	....	....	....	....	....	....	4	0.05
Zygospore	....	2	....	....	....	....	1	....	....	3	....	....	2	....	....	....	....	....	....	....	8	0.1
Dimorphococcus	4	8	4	5	3	2	1	....	....	....	2	1	....	3	1	....	....	....	....	....	34	0.4
Zygnema	....	....	....	x	....	....	x	x	....	x	....	x	x	x	....	....	....	....	....	....	....	....
Oedogonium	....	....	....	....	....	....	....	....	....	x	x	x	....	x	....	....	....	....	....	x	....	....
Eudorina	....	....	....	....	....	....	....	....	1	7	....	....	....	....	....	....	....	....	....	....	8	0.1
Bulbochacte	....	....	....	....	....	....	x	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
ROUND WORM																						
Nematode	....	3	5	....	....	....	2	1	....	2	....	....	....	....	....	....	....	....	....	....	13	0.1
Contracaecum	....	....	....	....	....	....	....	....	....	1	1	....	....	1	1	....	....	....	....	....	4	0.06
Acanthocephala	2	....	....	2	3	1	3	4	1	15	11	5	3	4	15	....	3	....	7	1	80	1.1
ROTIFERS																						
Anuraea	12	3	2	2	1	....	4	6	....	8	3	2	2	....	....	....	....	1	....	....	45	0.6
Monostyla	2	....	....	....	....	5	....	....	3	2	2	1	....	....	....	....	....	....	....	....	15	0.2
CLADOCERA																						
Bosmina	3	5	7	13	8	6	9	24	11	22	9	8	....	....	3	....	....	....	....	....	128	1.8
Acroperus	4	1	3	4	....	1	....	15	1	18	12	16	8	....	1	....	....	....	....	....	84	1.2
Alona	....	1	....	....	2	1	....	....	....	....	....	....	....	....	....	....	1	....	....	....	5	0.07
Chydorus	....	....	....	....	....	....	....	....	....	3	....	....	....	....	....	....	....	....	....	....	3	0.03
Unidentified	....	....	....	....	....	....	....	1	....	....	....	....	....	....	....	....	....	....	....	....	1	0.01
COPEPODA																						
Cyclops	4	17	3	7	5	9	7	10	6	11	6	9	8	....	1	....	....	....	....	....	103	1.4
Nauplii	....	7	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	7	0.1
Canthocamptus	....	9	14	3	11	7	11	16	....	17	3	....	1	1	....	....	....	....	....	....	95	1.3
OSTRACODA	....	....	....	....	2	2	....	....	....	....	1	....	....	....	....	....	....	....	....	....	5	0.07
MALACOSTRACA	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	1	....	....	....	2	0.02
HYDRACARINA	....	2	....	....	....	2	1	....	....	....	3	2	2	....	....	....	....	....	....	....	12	0.2
HEXOPODA																						
Larvae (total)	8	6	7	10	3	7	12	22	3	11	46	17	9	13	20	....	6	....	....	3	202	2.8
Ceratopogon	....	....	....	....	....	....	2	1	1	....	2	1	....	....	....	....	....	....	....	....	7	0.1
															x		x	x	x	x		
Insect remains	x	x	x	x	x	x	x	xx	xx	xx	xx	x	xx	xx	xx	x	xx	xx	xx	xx		

x present—several filaments
xx much—more
xxx very much—too many to count

The fish in a third group, the largest of those present, measuring from 27 to 32 mm., contained more animal food. The principal food consisted of adult oipterous insects. As far as could be determined, the larvae were those of the Chironomidae, while the adult insects seemed to be mosquitoes. Most of the insect remains were so well digested that complete identification was not possible.

Ten specimens of the minnows studied, ranging from 23 to 32 mm. in length, contained embryos.

While working on the food of the minnows, some interesting parasites were found, all belonging to the group Nemathelminthes. Several very large round worms occurred in the body cavity of male fish. These worms are typically coiled and lie next to the digestive tract, appearing to be a part of it. The space occupied by the parasite is about equal to that filled by the intestine as a whole. The body of the fish is distended and the parasite is visible through the flesh of the fish, as a pale yellow mass. In every case in which the worm was present, the intestine of the fish had become thin and mucilaginous, so much so that the walls disintegrated at the touch of the dissecting needles. Mr. E. W. Price, of the Bureau of Animal Industry, examined some of these worms and found them to be immature specimens of *Contracaecum*, too young to be identified specifically. A letter from Dr. Hildebrand states that in a large swamp near Huntsville, Alabama, he found many male fish, but no females, parasitized with (presumably) the same worm.

Within the intestine of more than half of the fish examined, there occurred parasitic nematodes and specimens of *Acanthocephala*, often in great numbers.

Since *Gambusia holbrooki* is apparently of great value as a mosquito exterminator, it would seem desirable that more work be undertaken in the way of investigating its food habits. At present an investigation is in progress at the University of Minnesota in which an examination of fishes, collected from Lake Aurora at intervals of every two weeks during the winter and spring months, is being made.

The writer wishes to thank Dr. S. F. Hildebrand and Professor Josephine E. Tilden for helpful criticisms.

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Discussion

MR. LAIRD: How far north do the Gambusia go?

MISS WARD: The range is about to the Dismal Swamp in Virginia, but they have been raised in California, I do not know just how far north.

MR. LAIRD: They do not come to New Jersey and New York State?

MISS WARD: No, I understand they cannot stand freezing.

MR. VIOSCA: I have found that in ponds which freeze once or twice every year the Gambusia are not adversely affected, but the freeze does not last for more than forty-eight hours in the area to which I refer. There is probably a limit to what they can stand in the way of freezing.

MR. TITCOMB: Is there any other species which will replace it in a more northern climate?

MISS WARD: I am not so familiar with it myself, but there is this eastern species, *Gambusia holbrooki*, and there is the more western species found in Texas, *Gambusia patruelis*. These are the only two I know of.

DR. DAVIS: Several years ago the Bureau stocked some of these in Washington, and the waters have been full of them ever since.

PRESIDENT LECOMPTE: I know we have the Gambusia in Maryland, and we have freezing weather, very early, as a rule—usually in November and December. So that they will stand some freezing.

MR. VIOSCA: It seems to me that the number of species of the Gambusia is open to dispute. I recognize only one species, but perhaps a number of racial varieties. From the mosquito control standpoint it does not make any difference which one we have. The Gambusia in the Mississippi valley perhaps show less variation going from north to south over several hundred miles than you would find in going from stream to stream east and west in the gulf coastal plain, due to the fact that it is easier for them to migrate up and down a single river system than from one system to another.

Mr. Titcomb: May I ask Dr. Davis what the Bureau recommends when they receive inquiries for some species of mosquito killing fish for a northern climate?

Dr. Davis: I am not so familiar with that as I might be, but I understand that they commonly recommend some species of fundulus.

Mr. Chute (Illinois): It is not my intention to start any argument about the species of Gambusia, but I know that in Brookline, a suburb of Boston, Massachusetts, some Gambusia from Florida were planted in order to abate the mosquito nuisance, and the Gambusia have established themselves in that pond; there are hundreds where originally there were only about fifty. As they were placed there about five years ago, it would seem that under certain conditions they can stand the cold weather.

OBSERVATIONS ON THE SPAWNING TEMPERATURE OF LUXILUS CORNUTIS

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With the idea that water temperature is an important factor as to the time of spawning of the Shiner, *Luxilus cornutis* (Mitchill), observations were made during the 1928 and 1929 seasons at Big Sandy Lake, Minnesota.

The 1928 Season. On June 1st, the first minnows appeared along the shores in schools. The day was warm without any wind while the water temperature was 68° F. Two large schools were seen on similar type of shores. The shores consisted of sand and small rocks with a gradual sloping bottom. The minnows were in water one to three feet deep and three to ten feet from shore. The shiners in the school moved about rapidly and furiously giving the water the appearance of boiling. Since bait dealers seined and caught the two schools, their numbers were reported as 600 dozen in one school and 800 dozen in the other.

The 1929 Season. The spawning of the shiner occurred between the 24th and 29th of June. During the period May 15-17, only male shiners were seen. June 9-13 and June 15-19, females were seen containing spawn. June 29th, 200 shiners were examined which contained no spawn except one. Spawning occurred during the period June 24th to 29th. The water temperature at this time was 66°-70° F. The water temperatures for the time of observations were:

May 17—54°F	June 10—65°F	June 18—65°F	June 30—70°F
May 18—54 "	June 11—63 "	June 19—65 "	July 1—70 "
May 19—54 "	June 13—64 "	June 24—66 "	July 4—70 "
June 9—67 "	June 16—64 "	June 29—70 "	

In these two observations of the spawning habits of the shiner, spawning did not occur until the water temperature was between 66°—70°F.

Since definite and complete information concerning the spawning time and habits of Luxilus cornutis are lacking, it is hoped that these two observations will be of value in furthering interest in this minnow.

NOTES IN THE EXPOSURE OF SEVERAL SPECIES OF FISH TO SUDDEN CHANGES IN THE HYDROGEN-ION CONCENTRATION OF THE WATER AND TO AN ATMOSPHERE OF PURE OXYGEN.

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Exposure of Fish to Sudden Changes in the Hydrogen-ion Concentration.

Many people have believed that the hydrogen-ion concentration of the water is a factor that may limit the distribution of certain species of fish in our streams and lakes. For instance, it was held not so long ago that trout in general showed a distinct preference for water that had a slightly acid reaction. More recently, however, some people have begun to doubt whether the hydrogen-ion as such has any direct effect on the distribution of fish. This, of course, does not mean that fish can tolerate any degree of acidity or alkalinity whatsoever, it means that fish can probably tolerate the entire range of hydrogen-ion concentration as it occurs in unpolluted natural waters.

In a recent paper Creaser has shown that the brook trout, for instance, can tolerate a pH range from 4.1 to 9.5. Jewell and Brown report that the pickerel, the bullhead, and the yellow perch stood a transfer from water having a pH range of 4.4 to 6.4 to water having a pH range from 8.2 to 8.7, also that the reciprocal transfer from acid to alkaline water was withstood by the perch, the bullhead, and the bluegill. Jobes and Jewell reported that changes in the pH of the water were not correlated with variations in the pH of the blood. To determine whether our pond fish can stand sudden changes in pH, a number of experiments have been performed. Since these experiments are reported fully elsewhere, they will not be repeated in detail; only the results will be stated. For the sake of economy the expression pH will be used instead of the expression hydrogen-ion concentration.

For the benefit of those that are not acquainted with this type of work it may be stated that the pH scale is the measure of the relative abundance of alkaline and acid radicals in the water. The condition when the alkaline radical and the acid radical are present in equal concentrations is called neutrality. On the pH scale this corresponds to a value of 7. Values greater than 7 indicate that the water is alkaline in reaction,

or that the alkaline radical is present in greater amounts than the acid radical; pH values less than 7 indicate that the water has an acid reaction and that the acid radical predominates.

Experiments performed with the green sunfish show that this species tolerates rapid changes of pH from 7.2 to 9.6, and from 8.1 to 6.0. These experiments were performed at temperatures ranging from 17 to 19½ degree centigrade, and with a concentration of dissolved oxygen ranging from 4 to 8 p.p.m. Experiments with the orange spotted sunfish show that this species of fish is less resistent to extensive changes in the reaction of the water but a majority of the fish tested tolerated rapid changes from 7.9 to 9.2 and 8.1 to 6.0, when the dissolved oxygen amounted 8 p.p.m. At higher concentrations of dissolved oxygen the orange spotted sunfish tolerate a rapid change of pH from 7.9 to 9.6. That the orange spotted sunfish can tolerate water having a high pH is shown by the fact that these fish were observed spawning in water having a pH of 9.3. McClendon gives the pH range for this sunfish as 6.7 to 7.7. Apparently the orange spotted sunfish tolerates a much wider range of pH then is indicated by McClendon's figures. Goldfish tolerated a rapid change from pH 7.2 to pH 9.6.

Fingerlings of the large-mouth black bass ranging in size from 3½ to 6 in. in length tolerated rapid changes in pH from 8.1 to 6.0; from 7.25 to 9.3; from 9.2 to 6.1, and from 6.1 to 9.5. In some of these experiments with the large-mouth black bass the dissolved oxygen amounted to less than 4 p.p.m. Fingerlings of the large-mouth black bass and small-mouth black bass ranging in length from 1½ in. to 2¼ in. in length tolerated fairly rapid changes from 8.0 to 9.35, and from 8.6 to 6.0. The dissolved oxygen in these experiments ranged around 7 p.p.m. and the temperature varied from 23½ to 25 degrees centigrade. Fry of the small-mouth bass tolerated a sudden transfer from 9.3 to 6.6, and rapid changes from 7.2 to 8.3; from 9.3 to 7.7; from 7.7 to 9.7; and from 9.6 to 7.5.

The fry of the large-mouth black bass were also tested but they seemed to be somewhat less resistent to the high pH values than were the fry of the small-mouth.

Bluegill ranging in size from 2 in. to 4 in. in length showed distinct signs of discomfort, and several of them were lost, when the pH was raised rapidly from 7.9 to 9.6 when the dissolved oxygen was around 5 p.p.m. The experiment was repeated using an equal number of fish of the same size and using water having a concentration of dissolved oxygen of

about 24 p.p.m. Under these conditions the fish stood the change in pH without any trouble. They never quit feeding and no fish were lost. This experiment was repeated a second time at a concentration of O_2 of approximately 10 p.p.m. At this concentration of O_2 the fish tolerated the change from 7.6 to 9.5. They kept on feeding and showed no signs of distress. It is quite apparent from the results with the bluegill and with the orange spotted sunfish that the amount of oxygen in the water is a determining factor as to whether the fish can stand the highly alkaline water or not. Fortunately under natural conditions a high degree of alkalinity of the water is reached only when the dissolved oxygen is high. Only in water in which there is an abundant growth of submerged vegetation will the water become strongly alkaline. But while photosynthesis uses up the CO_2 dissolved in the water and thereby raises the alkalinity, it at the same time produces an excess of oxygen which enables the fish to stand the high degree of alkalinity of the water.

It is quite apparent from these results that under natural conditions two species of bass, the bluegill, the goldfish, the green sunfish, and the orange spotted sunfish can tolerate a wide range of pH and that in all probability the hydrogen-ion concentration does not directly affect the distribution of these species of fish.

Can Fish Live in Water With an Atmosphere of Pure Oxygen Super-Imposed over the Surface of the Water?

Experiments performed with large-mouth black bass show that this species of fish from the fry stage 0.5 in. in length to the fingerling stage 6 in. in length can live in water under an atmosphere of pure oxygen. The same is true also of the small-mouth bass ranging from the fry stage to 5 in. in length; of rainbow and brook around 2½ in. in length, of the black crappie ranging in length from 2½ in. to 4 in., and for bluegill ranging from 1½ in. to 4 in., golden shiners ranging in size from 2 in. to 5 in. in length, and goldfish ranging in length from 2½ in. to 4 in. In these experiments oxygen values as high as 40.33 p.p.m. were obtained, but this high concentration of oxygen seemed to have no deleterious effect on the fish. In these experiments it was also brought out that bass, for instance, could stand a sudden transfer from water containing 5.6 p.p.m. to water containing 40.33 p.p.m. of dissolved oxygen, and also the transfer from water containing 41.0 p.p.m. to water containing 7.3 p.p.m. of dissolved oxygen.

Can Pond Fish Live in Water Under Pressure in Excess of One Atmosphere?

Several people have told me that fish can not be subjected to pressure, but no one seemed to have any evidence or experimental data bearing on this question. That seemed sufficient reason for trying a few experiments in subjecting fish to pressure.

Three pressure experiments are here given in detail:

EXPERIMENT 1.

This experiment was conducted in a glass carboy of approximately 54 litres capacity. The carboy was completely filled with water before the fish were introduced. After the fish had been placed in the container, about one-third of the water was displaced by oxygen. Thus a super-stratum of pure oxygen was obtained. After a sufficient amount of water had been displaced the pressure was raised to 7.94 lbs. This pressure was attained at 8:15 A. M. February 21 and was maintained until 8:15 A. M. February 22. The fish used were; 2 bluegill (2½ in.), 3 goldfish (3¼ in. to 4 in.), 3 large-mouth black bass (5 in. to 6 in.), and 5 golden shiners (2.5 in. to 4.5 in.)—this does not include several shiners that were eaten by the bass during the experiment. At the end of a 24 hour period the oxygen tank was disconnected and compressed air was substituted for aeration. At no time during the course of this experiment did these fish show any signs of discomfort. After having been under a pressure, slightly in excess of 1.5 atmosphere of pure oxygen for 24 hours, all the fish except one bluegill and the shiners eaten by the bass were alive. The dead bluegill showed signs of external injury and had probably been worried by the bass. Other experiments showed that the bluegill did not succumb because of the high concentration of oxygen.

TABLE 1.

Shows values for dissolved oxygen in parts per million for experiment 1.

Time	O_2	Time	O_2	Time	O_2
Feb. 21		Feb. 22			
8:00 A. M.	7.04	2:45 A. M.	54.34	Feb. 24	
11:00 A. M.	27.06	4:45 A. M.	55.44	9:00 A. M.	23.54
1:00 P. M.	35.20	7:45 A. M.	57.2	12:30 P. M.	13.86
		O_2 disconnected			
4:00 P. M.	41.80	3:00 P. M.	47.3	Feb. 25	
6:00 P. M.	45.32	Feb. 23		8:00 A. M.	0
9:00 P. M.	49.50	11:00 A. M.	31.68		
12:00 P. M.	53.90	4:00 P. M.	30.30		

Two days and 13 hours after the termination of the experiment (at 5 P. M. February 24) the fish were all in good condition. During the following night the aerating machinery ceased to function and at 8:00 A. M. the next morning all the fish with the exception of one shiner were dead. A test made at that time showed an entire absence of dissolved oxygen. In spite of this tragic ending it appears that these fish had not been affected adveresly by the conditions of the experiment. This conclusion is borne out by further experiments.

The oxygen determinations made during the course of this experiment are shown in table 1. The temperatures are not shown in the table as the latter did not vary over 2° C., namely from 16° to 18° C.

Experiment 2.

A container having a capacity of 76.5 litres was completely filled with well water having the following characteristics: dissolved oxygen 8.0 p.p.m., free CO_2 14 p.p.m., pH 7.4, and a temperature of 22° C. Then 100 large-mouth bass fingerlings having a combined weight of 17 oz. were placed in the container after which the latter was sealed up tight. An oxygen tank was then connected and enough O_2 passed in to displace 16 litres of water and to raise the pressure to 13.23 pounds in a few minutes. This pressure was attained at 4:00 P. M. July 23. The experiment was discontinued at 8:00 A. M. July 15; i. e., after a period of 40 hours. There still was a pressure of 3.81 lbs. in the container.

Just before the pressure was released to take out the fish the water in the can had the following characteristics: O_2 18.0 p.p.m., free CO_2 53 p.p.m., pH 7.1, and temperature 22.5° C. One bass was dead at this time, the 99 remaining fish seemed unharmed. They were transferred to water having an O_2 content of 6.3 p.p.m. They were kept under observation until August 10, but no losses occurred. Hence it appears that being under pressure for 40 hours had not harmed them. These fish began to take artificial food within two days after they had come out of the experiment.

Experiment 3.

The procedure was the same as in the preceding experiment, but the pH and the free CO_2 of the well water were modified through the addition of NaOH. Hence the water had the following characteristics at the beginning of the experiment:

O_2 8.1 p.p.m., free CO_2 deficiency of 46 p.p.m., pH 8.8, and temperature 22.5.

100 large-mouth bass having a weight of 16 oz. were used in this experiment. A pressure of 13.23 lbs. was attained at 1:15 P. M. July 27. At 7:30 A. M. July 28 the pressure was 12 lbs. and the temperature 23° C. At 12 o'clock noon the pressure was 11 lbs., O_2 36.78 p.p.m., pH 7.9, (The value for pH would indicate that some free CO_2 was present). July 29 at 7:30 A. M. the pressure was 8.5 lbs., O_2 29.6 p.p.m., free CO_2 12 p.p.m., pH 7.4 and temperature 23.5° C.

On July 30 at 8:45 A. M. the O_2 amounted to 24.4 p.p.m., free CO_2 41 p.p.m., pH 7.2 and temperature 23° C. At 1:00 P. M. the pressure still amounted to 6.2 lbs., the O_2 to 23.6 p.p.m., free CO_2 42.0 p.p.m., pH 7.1, and temperature 24° C.

The fish were taken out at this time and transferred to water having an O_2 value of 7.1 p.p.m. One of the bass was on its side when the container was opened, but it recovered its balance in a few minutes and up to August 10, when the fish were liberated, no losses had occurred. These fish began to take artificial food soon after the experiment was terminated.

These three experiments show that bass can live under small pressures for 40 to 72 hours without any serious effect.

Additional experiments have shown that large-mouth black bass 1.25 in. to 2 in. in length, small-mouth bass fingerlings 1 in. to 1.5 in., trout (brook and rainbow) 2.5 in. in length, bluegill 1 in. to 5 in. in length, crappie 1 in. to 5.5 in. in length, golden shiners 4 in. to 5.5 in. in length and goldfish 2.5 in. to 3.5 in. in length can stand pressure from 11 to 14.33 lbs. for 24 hours even when an atmosphere of pure oxygen is maintained over the surface of the water.

In one experiment bass fingerlings were kept under a pressure ranging from 11 lbs. to 143 lbs. for 117.5 hours; 22 out of 50 survived the experiment. The loss of fish was probably due to the effect of CO_2 under pressure.

Summary

(1) Several species of fish have been subjected to higher concentrations of dissolved oxygen when an atmosphere of pure oxygen was maintained over the surface of the water and also with a super-stratum of pure oxygen under pressure.

(2) Several species of fish have been subjected to sudden transfers from low O_2 to high O_2 and the reverse. (5.6 p.p.m. to 40.33 p.p.m. and from 41.0 p.p.m. to 7.3 p.p.m.)

(3) The results show (a) that different sizes of several species of fish tolerate large and sudden changes in the concentration of O_2 in either direction, (b) that these fish can live in water containing a large excess of dissolved oxygen with a super-stratum of pure oxygen over the surface (c) that several species of fish can stand pressure of 10 to 13 lbs. for a period of 24 hours and pressures from 15 to 19 lbs. for shorter periods. (Longer periods not investigated).

(4) The increase in dissolved oxygen is followed by a slowing down of the respiratory movements.

(5) No instances of exophthalmus, opaqueness of the lens, and of the accumulation of gas bubbles were observed.

(6) No fish were observed to lose their equilibrium except in the pressure experiment where depression occurred too rapidly.

(7) That exposure to a high concentration of dissolved oxygen with a super-stratum of pure oxygen at atmospheric pressures and under small pressure is not harmful is inferred from the small number of fish lost and from the length of time they survived the experiment.

(8) The data presented here suggest that they may be applicable to the problem of handling fish in transportation.

Discussion

DR. WIEBE: In several of the states oxygen tanks are used to aerate the fish in the cans during transportation. The oxygen is simply bubbled into the water, and the rate at which that water can absorb oxygen is fixed not by the legislature but by natural law, and most of the oxygen thus bubbled into the water goes to waste.

It has been shown in Germany that even when a porous carbon cylinder is used, 93 per cent of the oxygen passing into the water is simply bubbled up to the surface and is never absorbed by the water, hence most of it is wasted. Of course oxygen is cheap nowadays, and that is perhaps not very serious.

It has occurred to me that if a proper kind of container could be constructed, by confining the oxygen that is going to bubble in anyhow under pressure you might be able to increase the load of fish. Some say we can increase it ten percent when the distance that the fish are hauled is not great. Ten per cent more fish would be a little saving, but it is even possible that we might increase the load to a greater extent than that. Of course we are using well water in these experiments, and all well water contains a good deal of CO_2. We added sodium hydroxide to remove the CO_2 and produce a CO_2 deficiency. That would take care of a good deal of the CO_2 that the fish would produce, if the

water as it comes out of the well has about fourteen parts per million of free CO_2. If we added enough sodium hydroxide to have a CO_2 deficiency of forty-six parts per million, that would mean that these fish could live in there at least an additional day. So that there are certainly possibilities in this work, although it was not undertaken with that end in view.

Dr. Hubbs: At our Institute of Fisheries Research at Ann Arbor, Michigan, we have carried out independently nearly all these experiments—not so extensively, but practically every type of experiment which Dr. Wiebe reported we have also done. It is gratifying to note that our results are practically in complete accord with the findings of Dr. Wiebe. We undertook these experiments with perhaps a somewhat less pure motive, namely, in order that we might be able to find some means of carrying a greater number of fish from the hatchery to the rearing stations or from the rearing stations to the streams or lakes.

There is one point on which we are in slight disagreement. In experimenting with landlocked salmon yearlings, when we took the fish from waters highly super-charged with oxygen and put them in water low in oxygen, they showed marked distress—contortions of the body —and most of them died as a result. That is the only part upon which we are in disagreement.

The last point mentioned by Dr. Wiebe with regard to the attention of hydroxide to the water is very interesting, because we have been trying quite a number of different substances in an effort to meet this increase in CO_2. In our experiments, most of which were performed in closed jars and in water which is also high in carbon dioxide to begin with, we found there was an increase in carbon dioxide, so we frequently got a loss during the experiment due to the increase in acidity on account of the carbon dioxide production by the fish.

We have used various materials; sodium bicarbonate has proved the most effective so far. We did not use hydroxide; I think it occurred to us that it was a little dangerous. I imagine it is a matter of getting exactly the proper concentration, and I would be much interested in finding out exactly what Dr. Wiebe did in that respect. With these landlocked salmon we ran the pressure up to fifteen pounds for several hours, and they survived that treatment very well.

The aquarium people as a whole are opposed to the use of oxygen; they say that it will increase the vigor of the fish while it is being used but invariably the fish will die, usually a number of days—perhaps Mr. Chute can give the exact figures—or at any rate some weeks following the treatment with the oxygen. We have not held any of our fish for a long period of time after the high oxygen treatment. You mentioned something of that sort—how long was it?

Dr. Wiebe: We have had some over two months at any rate.

MR. TITCOMB: What is the normal amount of oxygen required by the fish?

DR. WIEBE: That depends on many different things—temperature, the condition of the fish, whether he has just been fed or is on an empty stomach. I guess, however, he could get along comfortably on from three to six or seven parts per million.

MR. TITCOMB: What about trout?

DR. WIEBE: I am not supposed to know anything about trout, but I should say that it would not be safe to go below six parts per million.

DR. HUBBS: We kept one adult rainbow trout for weeks at I think about two parts per million. Finally he lost his appetite and died, perhaps through lack of food.

DR. WIEBE: I have kept bass at as low as one-half part per million but I would not recommend that a state board use that low concentration; I think it would be very dangerous.

MR. TITCOMB: We know that there are certain plants that require alkaline water and will not do well in acid water. We do not know all of the plants that will thrive in acid water, and I am hoping that sometime a biologist or specialist will make a thorough study of that question. It is one in respect to which we are profoundly deficient in knowledge, and one on which there are many differences of opinion.

MR. LANGLOIS: I suggest that pure curiosity might dictate another experiment to Dr. Wiebe. An excess of temperature will of course cause the death of a lot of fish; whether that is due simply to the higher temperature or to the reduced oxygen content of the warmer water, I do not know. Since Dr. Wiebe has the apparatus all set up for providing oxygen under any conditions, why not heat the water and see how much temperature they can stand?

DR. WIEBE: A good suggestion.

CAPTAIN CULLER: Mr. Surber made some very interesting observations on the upper Mississippi during this past summer and found that the temperature of some of the shallow sloughs ran as high as 104-2/10. In those waters there were a large number of fish, so it is evident that the fish can stand a very high temperature. I am speaking of the warm water species.

MR. TITCOMB: Apparently it all depends on the oxygen content. If you travel over a series of lakes in Canada, for example, you find that some of them have a pretty high temperature; but during a period when you have a temperature of say 83 on the surface of the lake and you come to a stream running over some falls with a lot of white water at the base, that is the place to catch your trout. At that point there is a great abundance of oxygen, and that is where the trout seem to congregate.

LETHAL CONCENTRATIONS OF ARSENIC FOR CERTAIN AQUATIC ORGANISMS

E. W. SURBER AND O. L. MEEHAN

U. S. Bureau of Fisheries

I. INTRODUCTION

During the summer of 1929, sodium arsenite treatments were administered to several sloughs in the Upper Mississippi Wild Life and Fish Refuge. The purpose of these treatments was to discover the approximate concentration of sodium arsenite solution which could be used to keep submerged vegetation under control and at the same time maintain aquatic organisms in sufficient numbers to maintain fish life in these ponds. A value of about 1.73 parts per million of arsenious oxide in the sodium arsenite solution was arrived at.

In treating ponds of an acre or more in area, elements of uncertainty enter when experimenting, which can be eliminated to a large extent in aquaria with controls. For example, in spraying the chemical over the surface of a pond there is the possibility that momentarily, at least, some of the organisms will be exposed to higher concentrations, others to lower concentrations than that which it is desired to maintain in the pond.

The experiments which are described in this paper were designed to check back directly on the observations made during 1929 regarding the effects of different concentrations of arsenic on important aquatic organisms which normally occur in fish ponds. The experiments were performed in laboratories of the U. S. Biological Station, Fairport, Iowa. The living organisms were obtained from the ditch pond located between Pond D7 on the station grounds and the Rock Island railroad right of way.

We are indebted to Dr. A. H. Wiebe, Acting Director of the Biological Station, for suggestions and courtesies during the conduct of these experiments.

II. METHODS

Small aquaria of clear glass, about eight inches in diameter and four inches deep and a few battery jars were used for retainers. 500 c. c. of water were used in the clear glass aquaria and 1000 c. c. in the larger green-glass battery jars.

There was ample surface area for absorption of oxygen in each vessel.

River water, obtained from the reservoir which supplies the ponds on the station and well water were used as culture media for most of the cultures.

The methyl orange alkalinity of the river averages about 150 p.p.m., and the well water about 390 p.p.m.

Stock solutions of arsenious oxide were made up by dissolving 500 mg. of c. p. $As_2 O_3$ in 100 c. c. of 20% NaOH. This was diluted to about 500 c. c. with distilled water, acidified with $H_2 SO_4$ and diluted again to a liter. Each c. c. of this solution contained .5 mg., of arsenious oxide. A stock solution of sodium arsenite was made by diluting the commercial sodium arsenite "Weed Killer, Four Pound Material," until a solution was obtained which contained about .5 mg. of arsenious oxide per c. c. of stock solution. The fact that one gallon of the Weed Killer dissolved in 64,082 cubic feet of water yields one milligram of arsenious oxide per 1000 c. c. of water was used as a point of departure in making the dilution calculations.

The stock solutions were checked by the Sanger-Black-Gutzeit method[1] to determine their actual arsenious oxide content. The water in the experimental aquaria was also checked during the five-day periods of exposure of the organisms to determine its actual arsenious oxide content. The results of these determinations are shown in the tables of results.

The Sange-Black-Gutzeit method which we have used in our arsenic determinations involves the evolution of hydrogen produced by the action of 20 c. c. of 7 $NH_2 SO_4$ on 10 grams of c. p. stick zinc placed on a perforated piece of platinum foil about a half inch square in a 30 c. c. evolution bottle. The hydrogen evolved unites with the element arsenic in 1-10 c. c. samples to form arsine which passes through tubes over lead acetate paper and cotton moistened with 3% lead acetate and is finally deposited on a strip of paper which has been dipped in a 5% alcoholic solution of mercuric chloride for 1 hour and dried in the air. The arsenic absorbed by the mercuric chloride paper produces a brown color. The length of the colored area present and the intensity of color developed, depend on the amount of aresinc present. The strips showing the amount of arsenic in samples from aquaria or ponds are compared with standards from

[1] Treadwell, F. P. and Hall, W. T., 1927. Analytical Chemistry, Vol. II, Quantitative Analysis, 6th Edition, p. 203-204. John Wiley and Sons, Inc., New York.

known quantities of arsenic. Although mercuric bromide standards are more permanent, we obtained greater uniformity using mercuric chloride, especially in the lower ranges of our standards. The color which developed with mercuric chloride seemed to possess higher quality and definiteness. After preparing several series of standards and plotting the results from measurements of colored areas on the strips, a graph was prepared and, thereafter, measurements, on strips were compared with values on this graph.

The stock solutions for the standards were prepared as follows: 132 mg. of $As_2 O_3$ were dissolved in 25 c. c. of 20% NaOH. This was diluted to about 450 c. c. with distilled water, acidified with $H_2 SO_4$ and diluted further to exactly one liter. 10 c. c. of this stock solution diluted to 250 c. c. gives a concentration of .004 mg. per c. c. Standards ranging from .004 mg. to 040 mg. were prepared. Samples from the aquaria were taken of sufficient size to strike about the middle of the range.

Two aquaria, one experimental and one a control, were used for each experiment. The aquaria were as nearly alike as possible so far as concerned volume of water, number of experimental organisms, depth of water, amount of light received, amount of food received, etc. The aquaria were placed on window sills, side by side, on the south and west sides of the museum room of the Biological building. The daily temperatures recorded at a point half way between surface and bottom in an aquarium on each side of the museum are given for the experimental periods (Table 8).

Some organic material such as bits of stems of aquatic plants were often placed in many of the aquaria to duplicate sparingly the natural environment of the various organisms used in the experiments. Since the concentrations of arsenious oxide or sodium arsenite are undoubtedly reduced by the presence of organic material, care was taken to measure volumes of oraginc matter or lengths of shoots of plants introduced. These measurements are recorded in the tables of results.

The matter of food for these organisms has already been mentioned above. It is a matter of importance to record, however, that plant food organisms, such as algae furnished the mayfly nymphs, were killed by the higher concentrations and probably ceased to be food after a day or more.

Most of the experiments extend over a period of five days. While it might have been desirable to have extended the experiments over a longer period of time, the problem of pro-

viding food in a normal condition became a serious one and starvation might have entered as an important factor of error.

The sodium arsenite and arsenious oxide solutions were added to the aquaria with ordinary volumetric pipettes.

TABLE 8.

Temperature recorded in aquaria during the experimental period. Aquaria were placed on window sills on the west and south sides of the museum room U. S. Biological Station, Fairport, Ia.

Month	Day	Year	Time of Day 8:00 A.M.	1:00 P.M.	4:30 P.M.	Side of Room
				°C	°C	
December	18	1930	......	23.5	23.0	....
"	19	"	20.6	......	......	....
"	20	"	14.5	......	......	S
"	"	"	13.0	......	......	W
"	22	"	14.5	15	......	S
"	"	"	13.0	13.5	......	W
"	23	"	12.5	22.5	23	S
"	"	"	6.5	18.5	19.5	W
"	24	"	15.5	23.0	23.5	S
"	"	"	12.5	21.5	22.5	W
"	26	"	14.5	16.5	16.0	S
"	"	"	13.0	14.0	13.5	W
"	27	"	15.0	22.5	23.0	S
"	"	"	9.5	18.5	19.5	W
"	29	"	14.5	20.0	19.5	S
"	"	"	9.5	18.0	18.5	W
"	30	"	12.5	24.0	19.5	S
"	"	"	8.0	18.5	19.5	W
"	31	"	15.0		......	S
"	"	"	10.0	15.5	......	W
January	1	1931	7.5	......	......	W
"	2	"	11.0	26	19.5	S
"	"	"	11.0	18.5	21.5	W
"	3	"	15.0	......	......	S
"	"	"	9.0	......	......	W
"	5	"	15.5	19.0	23.0	S
"	"	"	14.5	16.0	19.5	W
"	6	"	15.5	19.5	23.0	S
"	"	"	9.5	16.5	21.5	W
"	7	"	13.5	......	......	S
"	"	"	12.5	......	......	W

III. Summary and Results

The results of the experiments ar shown in detail in Tables 1–17. Some of the most important points are summarized as follows: Table I, shows 75 per cent survival of mayfly

nymphs of the genus *Caenis* in 2.94 p.p.m. of arsenious-oxide in well water; 38 per cent is recorded for *Caenis* nymphs in river water containing 7.84 p.p.m. $As_2 O_3$, the highest concentration tried. The lethal concentration is estimated at 3.0 p.p.m.

Eighty-eight and two tenths per cent survival is recorded for the mayfly nymphs of *Callibaetis* in 3.92 p.p.m. of river water, while only 6.2% and 5.8% are recorded in aquaria receiving 5.8 p.p.m. It appears from these data that the lethal point for nymphs of *Callibaetis* is about one part per million higher than *Caenis* or 4.0 p.p.m.

Table No. 2 gives some rather astonishing data regarding the concentrations of arsenic which can be survived by dragonfly nymphs of the genus *Libellula*. For example 95.9% of survival is recorded for these animals after exposure to 14 p.p.m., of arsenious oxide in river water. In another experiment 95.3% of survival was recorded after exposure to 14 p.p.m., $As_2 O_3$ in a treatment with sodium arsenite. A lower survival rate was noted in aquaria which did not receive debris for a substratum when only 56% of the initial number of organisms survived. The two experimental aquaria in which the high percentage of survival are recorded received 70 c. c. and 104 c. c. of debris, respectively.

The damselfly nymphs, *Ischnura verticalis,* Table 3, obtained as much as 85.4% survival after exposure to 11.2 p.p.m. of As_2O_3 in well water. Peculiarly, a slightly higher percentage of survial was recorded in the experimental than in the control indicating that arsenic may not have been a factor in causing mortality.

Table No. 4 shows that midgefly larvae (Chironomidae) exhibited high survival rates in 1.96 p.p.m. of arsenious oxide, but that the treatments of that concentration were acting as a factor in mortality. In two experiments 82.6% and 83.3% of survival were recorded for the experiments while 96% of the organisms survived the control.

When chironomids were placed in 3.92 p.p.m. of the c. p., $As_2 O_3$, the rate of mortality increased, amounting to about 35% of survival in both well and river water, while the control showed 65% of survival. Handling the larger larvae without injury was not an easy matter and they appeared to suffer from it. They were handled with droppers and forceps.

When sodium arsenite was used, as much as 93.3% of survival was obtained with small chironomids 5.4 m.m. in length

at 7.0 p.p.m., while only 26.6% of large chironomids 10 m.m., in length survived the same concentration.

The fresh water Isopod, *Asellus communis,* Table No. 5, appears capable of resisting very high concentrations of arsenic. In one experiment, 81.2% of survival was recorded after treatment with 21 p.p.m., of arsenious oxide equivalent in sodium arsenite solution. The survival rate was lower in the control in this case. (77.4%).

Water mites (Hydracarina), Table 6, were also relatively unaffected by high concentrations of arsenic. In a 10.5 p.p.m., treatment with sodium arsenite, 94% of the mites survived in river water.

The lethal concentration for the fresh-water amphipod (fresh-water shrimps) *Hyalella knickerbockeri,* Table 6, appears to be about 4.0 p.p.m., 92% of survival was recorded in river water which received 3.92 p.p.m., of arsenious oxide while only 30% of survival was recorded after a treatment of 5.88 p.p.m.

It seemed probable that simple, single-called organisms such as the Protozoa would afford better material for toxicity experiments. A hay infusion culture was prepared from boiled Timothy hay. Within a few days such organisms as *Colpidium, Paramecium,* and *Stylonichia* became numerous enough to experiment with. A hay infusion culture in which *Colpidium* was the predominating organism was treated with 3.5 p.p.m. of As_2O_3 solution. There were 16,000 individuals per c. c., in this culture just before treatment. At the end of 24 hours the number had increased to 20,400 per c. c. In comparison, there were 9,972 *Colpidium* per c. c. in the control culture at the beginning of the experiment and 10,680 after 24 hours (Table 7).

The same concentration (3.5 p.p.m.) was tried out on cultures of *Paramecium.* In the experimental culture there were 246 organisms per c.c., at the beginning of the experiment and 744 per c.c., after 71 hours and 45 minutes. In the control, the initial number was 232, the final number 640 per c.c., at the end of about 72 hours (Table 7).

A similar experiment with *Stylonichia* at 3.5 p.p.m., of As_2O_3 yielded similar results. The initial number of organisms in this case was 292, the final 2,672 after three days. In the control, the initial number was 222 per c.c., the final 1,496 per c.c. (Table 7).

The horse-manure-garden-soil-pond water culture of Banta[1] was used to culture species of Cyclops. An experiment with

[1] Banta, A. M., 1921. Science, N. S., Vol. 53, No. 1381, pp. 557-558, June 17, 1921.

Cyclops in this medium yielded the following results: A 3.5 p.p.m., treatment was administered to a culture containing 2,016 adult Cyclops and 1,008 nauplii per 500 c.c., of culture. At the end of 123 hours and 15 minutes, 600 adult Cyclops and 12 nauplii remained per 500 c.c., of culture. The control gave similar results, however, showing that the arsenic was not responsible for the large reduction in numbers of the experimental animals.

The green alga, *Spirogyra,* cultured in 3% Knop's solution was the object of an experiment which yielded the following results: A treatment of 1.75 p.p.m., produced a condition in the cells at the end of 44 hours and ten minutes which resembled plasmolysis. The spiral chloroplasts were also drooped or straightened in many cells in comparison to the perfect spirals in the cells of the control. The filaments continued to live, however, for some time after the experiment was discontinued (Table 7).

A study of the rate of decrease of arsenic in samples taken after the initial treatment at a point approximately half way between surface and bottom showed the following results: (1) The As_2 O_3 content of the samples in aquaria receiving small treatments of from 0 - 2.99 p.p.m., decreased very rapidly. The average percent of reduction in river water after two days was 92.8% while it was 99.6% in well water, (2) Treatments of from 3.0 - 7.9 p.p.m., As_2 O_3, showed a five-day average reduction of 73.5% in river water and 84.2% in well water, (3) The average percentage of reduction in river water receiving from 3.0 - 7.9 p.p.m., As_2 O_3 was 76.7%.

Higher results could be obtained upon stirring the aquaria indicating that the arsenic must be precipitated out after combining with certain elements, probably calcium or iron.

It is likely that different amounts of organic matter placed in the experimental aquaria influenced the rate of reduction of arsenic, but, with the exception of a very few cases, the data does not permit comparison from which definit conclusions can be made.

IV. Conclusion

Fish culturists who might wish to use this chemical in the control of bothersome submerged vegetation in fish ponds may receive some encouragement from the fact that a treatment of 2.0 p.p.m. of arsenious oxide equivalent in sodium arsenite "Weed Killer" solution will not cause the important fish food organisms to die on exposure to the chemical. Chiro-

nomid larvae, mayfly nymphs and fresh-water shrimp, *Hyalella*, appeared to be most sensitive to the treatments with relatively high mortality rates following exposure to 2.5 - 4.0 p.p.m. of As_2O_3.

Damselfly and dragonfly nymphs, *Asellus* and water mites survived concentrations of 10.5 - 21 p.p.m., of $As_2 O_3$.

The protozoa, *Colpidium, Paramecium,* and *Stylonichia* survived and multiplied when exposed to 3.5 p.p.m., $As_2 O_3$.

The green alga Spirogyra was affected by a treatment of 1.75 p.p.m. $As_2 O_3$, but was not killed by it.

The quantity of arsenic is reduced rapidly in aquaria when samples are taken at some distance from the bottom. The amount of reduction is about 75 per cent in five days with concentrations of 3.0 - 7.9 p.p.m., but is more rapid when smaller concentrations are used. Stirring water in the aquaria before taking a sample increased the amounts of arsenic in samples indicating that the arsenic is percipitated out by elements present in the water.

TABLE NO. 1.

TOXICITY EXPERIMENTS WITH THE MAYFLY NYMPHS, CAENIS DIMINUTA (WALKER) AND CALLIBAETIS SP.

Aquarium No.	Kind of organism	Kind of Water	p.p.m. of As_2O_3 added	Date	As_2O_3 present in subseq. analysis p.p.m.	As_2O_3 present in subseq. analysis Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
11	Caenis	River	0.00	12/18/30	0.0	12/20/30	100	95	95	Contained 29 cm. of Ceratophyllum
3	Well	”	.98	”	.016	”	120	108	90	Contained 43 cm. of ”
21	River	”	.98	”	0.4		100	93	93	” 34 ” ” ”
11	”	”	0.0	12/20/30	0.0	12/26/30	94	84	89.3	” 25.5 ” ” ”
21	”	”	3.92	”	1.76:1.2	12/21:12/23	94	43	45.7	” 29.0 ” ” ”
3	”	Well	2.94	12/22/30	.04	12/27/30	108	81	75	
11	”	River	0.00	12/26/30	0.00	12/31/30	63	35	55.5	These organisms dosed in No. 21 of 12/20/30
21	”	”	5.88	”	1.48	”	64	10	15.6	
11	”	”	0.0	1/2/31	0.0	1/7/31	50	49	98	
21	”	”	7.84	”	1.2	”	50	19	38	
The above aquaria were treated with arsenious oxide.										
10	Caenis	River	0.0	1/7/31	0.0	1/13/31	40	38	95	
31	”	”	7.0	”	6.16:2.28	1/9:1/13	40	2	5	
25	”	”	0.0	1/7/31	0	”	40	36	90	Kept for three weeks in large aquarium before treated.
21	”	”	10.5		4.35:10.4 7.0:4.96	1/7:1/8 1/9:1/13	40	1	2.5	
24	”	”	14.0	1/8/31	9.6	1/14/31	50	0	0	
10	”	”	0.0	1/13/31	0.0	1/19/31	37	33	89.1	
25	”	”	4.2	1/13/31	3.6:1.84 1.0	1/13:1/16 1/19/31	50	10	20	
The above aquaria were treated with sodium arsenite.										
12	Callibaetis	River	0.0	12/18/30	0.0	12/20/30	17	17	100	
20	”	”	1.96	”	0.2	”	17	17	100	11 molted skins
12	”	”	0.0	12/20/30	0.0	12/23/30	17	17	100	5 ” ” ; 22 cm. of Ceratophyllum
20	”	”	3.92	”	2.62:2.24	12/21:12/23	17	15	88.2	2 ” ” ” ” ”
12	”	”	0.0	12/26/30	0.0	12/31/30	16	16	100	11.5 ” ” ”
20	”	”	5.88	”	1.04	”	16	1	6.2	20 ” ” ”
20	”	”	5.88	1/2/31	1.04	1/7/31	17	1	5.8	11.5 ” ” ”

The above aquaria were treated with arsenious oxide.

TABLE NO. 2.

TOXCITY EXPERIMENTS WITH THE DRAGONFLY NYMPHS, LIBELLULA SATORATA (NEEDHAM) AND L. PUCHELLA (NEEDHAM).

Aquarium No.	Form of arsenic	Kind of water	p.p.m. of As_2O_3 added or equiv.	Date	As_2O_3 present in subseq. analysis p.p.m.	Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
8	Arsenious oxide, C. P.	River	0.0	12/18/30	0.0	12/20/30	40	38	95	35 c.m. of Ceratophyllum
24	"	"	1.96	"	.02	"	40	39	97.5	57 " " "
13	"	"	0.0	"	0.0	12/22/30	30	29	96.6	52 c.c. of debris
4	"	Well	.98	"	0.0	12/20/30	50	50	100	55 " " " 62 c.m. of Ceratophyllum
17	"	River	.98	"	0.0	"	50	49	98	
8	"	"	0.0	12/20/30	0.0	12/26/30	38	33	96.8	57 " " " 49 " " "
17	"	"	2.94	12/22/30	0.0	12/27/30	49	49	100	23 " " "
24	"	"	3.92	12/20/30	2.84:0.24	12/21:12/23	38	29	76.3	70 " " " 38.5 " " "
13	"	"	7.84	12/22/30	.64	12/27/30	29	29	100	25 " " "
4	"	Well	11.2	"	0.6	"	50	45	90	105 " " " 59.5 " " "
8	"	River	0.0	12/26/30	0.0	12/31/30	31	27	87	55 " " "
24	"	"	5.83	"	0.98	"	31	31	100	20.5 " " "
13	"	"	0.0	12/29/30	0.0	1/7/31	29	28	96.5	23.0 " " "
17	"	"	14.	"	2.88	1/3/31	49	47	95.9	105 " " "
8	"	"	0.0	1/2/31	0.0	1/7/31	29	25	86.2	70 " " "
24	"	"	7.84	"	2.32	"	29	21	72.4	13 " " "
30	Sodium Arsenite	"	0.0	1/6/31	0.0	1/13/31	50	48	96	15 " " " 85 " " "
28	"	"	7.0	"	1.28:1.04	1/9:1/13	50	45	90	80 " " "
8	"	"	0.0	1/7/31	0.0	1/13/31	20	16	80	
11	"	"	14.0	"	6.8:2.8	1/9:1/13	50	28	56	50 c.c. of debris
1	"	"		1/13/31	0.0	1/19/31	73	47	64.3	Probably not enough food
28	"	"	14.0	"	14.0:2.4 1.2	1/14:1/16 1/19/31	65	62	95.3	104 c.c. of debris

TABLE NO. 3

TOXICITY EXPERIMENTS WITH THE DAMSELFLY NYMPHS OF ISCHNURA VERTICALIS (SAY).

Aquarium No.	Form of arsenic	Kind of water	p.p.m. of As_2O_3 added or equiv.	Date	As_2O_3 present in subseq. analysis p.p.m.	Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
10	Arsenious Oxide, C. P.	River	0.0	12/18/30	0.0	12/20/30	50	44	88	17.5 c.m. of Ceratophyllum
22	"	"	1.96	"	0.3	"	50	47	94	32 " " "
5	"	Well	.98	"	0.0	"	75	74	98.6	68 c.c. of debris; 89 c.m. of Ceratophyllum
16	"	River	.98	"	0.0	"	75	72	96	92 " " " 111 " " "
10	"	"	0.0	12/20/30	0.0	12/23/30	44	28	63.6	17 " " "
22	"	"	3.92	"	3.22:1.2	12/21:12/22	44	40	90.9	19.5 " " "
16	"	Well	0.0	12/22/30	0.0	12/27/30	72	60	83.3	92 c.c. of debris
5	"	"	7.84	"	0.8	"	74	68	91.8	23 " " " 58 " " "
10	"	River	0.0	12/26/30	0.0	12/31/30	34	21	61.7	18.5 " " "
22	"	"	5.88	"	1.76	"	34	25	73.5	17.5 " " "
5	"	Well	0.0	12/29/30	0.16	1/3/31	68	62	91.1	50 " " "
16	"	"	9.80	"	1.04	"	60	57	95	92 " " "
5	"	"	0.0	1/3/31	0.0	1/8/31	57	48	84.2	Some Spirogyra
16	"	"	11.20	"	4.0	"	55	47	85.4	26.5 " " "
33	Sodium arsenite	River	0.0	1/7/31	0.0	1/13/31	30	26	86.6	
32	"	"	7.0	"	4.0:1.48	1/9:1/13	30	27	90	

TABLE NO. 4.

TOXICITY EXPERIMENTS WITH MIDGE LARVAE. SPECIES: (SEE BELOW).

Aquarium No.	Kind of organism	Kind of water	p.p.m. of As_2O_3 added	Date	As_2O_3 present in subseq. analysis p.p.m.	Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
9	Chironomid larvae	River	0.0	12/18/30	0.0	12/20/30	75	72	96	20.5 c.m. of Ceratophyllum
23	"	"	1.96	"	.008	"	75	62	82.6	24.0 " " "
6	"	"	1.96	"	.012	"	60	50	83.3	21.5 " " "
9	"	"	0.0	12/20/30	0.0	12/23/30	66	43	65.1	25.5 " " "
23	"	"	3.92	"	2.0:1.12	12/21:12/23	66	22	33.3	17.8 " " "
6	"	Well	3.92	12/22/30	1.0	12/27/30	49	17	34.6	These organisms dosed in No. 6 on 12/20/30
9	"	River	0.0	12/24/30	0.0	12/31/30	31	10	32.2	Algae (Spirogyra) alive in aquar
23	"	"	5.88	"	.8	"	31	2	6.4	" " dead
All of the above aquaria were treated with arsenious oxide, C. P.										
27	"	"	0.0	1/7/31	0.0	1/13/31	50	28	56	
9	"	"	3.5	"	1.04:0.53	1/9:1/13	50	23	46	
22	"	"	7.0	"	2.68:1.6	"	50	15	30	
22	"	"	7.0	1/13/31	6.0:2.2 1.2	1/13:1/16 1/19/31	60	59	98.3	New group of Chironomids Small individuals av. lg. 5.4 m.m.
21	"	"	7.0	"	6.4:1.12 1.34	1/13:1/16 1/19/31	50	16	26.6	26 were from aquar, No. 27 of 1/7/31 24 new indi. Large: 10 m.m. long

The above aquaria were treated with sodium arsenite.

The species of Chironomidae are; Cricotopus trifaciatus (Panzer); Chironomous tentans (Fabracius); Protenthes culiciformis (Linne); the last two being most common.

TABLE NO. 5.

TOXICITY EXPERIMENTS WITH THE FRESH WATER ISOPOD ASELLUS COMMUNIS (SAY).

Aquarium No.	Form of arsenic	Kind of water	p.p.m. of As_2O_3 added	Date	As_2O_3 present in Subseq. analysis p.p.m.	Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
7	Arsenious oxide	River	0.0	12/18/30	0.0	12/20/30	56	51	91	65 c.c. of debris; 17.5 cm. of Ceratophyllum
25	"	"	1.96	"	.04	"	56	55	98.2	60 " " " 46.5 " " "
19	"	"	1.96	"	0.0	"	40	39	97.5	89 " " " 17 " " "
7	"	"	0.0	12/22/30	0.0	12/27/30	45	45	100	65 " " " 38 " " "
19	"	"	3.92	"	0.06	"	45	45	100	60 " " " 32.5 " " "
25	"	"	5.88	"	0.08	"	55	55	100	31 " " "
7	"	"	0.0	12/27/30	0.68	1/8/31	45	38	84.4	60 " " "
19	"	"	7.84	"	0.04	"	45	45	100	70 " " " 48.5 " " "
7	Sodium arsenite	"	0.0	1/8/31	0.0	1/13/31	50	48	96	40 " " " too much fert. added
19	"	"	10.5	"	6.4:1.84	1/9:1/13	65	31	47.6	40 " " " " " " "
11	"	"	0.0	1/13/31	0.0	1/19/31	31	24	77.4	35 " " " Animals prev. dosed
7	"	"	21.0	"	13.3:3.52 2.04	1/13:1/16 1/19/31	48	39	81.2	100" " "

TABLE NO. 6.

TOXCITY EXPERIMENTS WITH WATER MITES OF THE FOLLOWING GENERA OR SP., LIMNESIA HISTRIONICA (HERMANS), HYDRACHINA S. P., CYCLOTHRIC, S. P., AND THE FRESH-WATER SHRIMP HYALELLA KNICKERBOCKER (BATE).

Aquarium No.	Kind of organism	Kind of water	p.p.m. of As_2O_3 added	Date	As_2O_3 present in subseq. analysis p.p.m.	Date	Initial No. organisms	No. Recovered alive	% Survival	Remarks
14	*Hydracarina	River	0.0	12/18/30	0.0	12/20/30	70	70	100	Debris present; 77.5 cm. of Ceratophyllum.
18	"	"	1.96	"	0.0	"	70	70	100	Ostracods, chironomid lv. present in this aquarium after treatment. Debris present, 33.5 cm. of Ceratophyllum. 34 c.c. debris.
2	"	Well	1.96	"	0.0	"	70	68	97	
14	"	River	0.0	12/20/30	0.0	12/23/30	92	73	79	
18	"	"	3.92	"	1.2:0.12	12/21:12/23	70	63	90	14.5 c.m. of Ceratophyllum.
2	"	Well	5.88	12/22/30	0.8	12/27/30	68	63	92	35 c.c. of debris
14	"	River	0.0	12/26/30	0.0	12/31/30	68	68	100	70 " " "
18	"	"	5.88	"	0.98	"	68	67	98	54 " " "
14	"	"	0.0	1/2/31	0.0	1/7/31	68	64	94	54 " " "
18	"	"	7.84	"	2.23	"	67	66	98	70 " " "
The above were treated with arsenious oxide.										
14	"	River	0.0	1/8/31	0.0	1/14/31	90	89	98	Without debris
20	"	"	10.5	"	tr.:tr.	1/13:1/14	90	85	94	" "
The above were treated with sodium arsenite.										
14	Hyalella Knickerbocker (Bate)	River	0.0	12/18/30	0.0	12/20/30	14	14	100	Debris present; 77.5 cm. of Ceratophyllum.
2	"	Well	1.96	"	0.0	"	14	13	92	34 c.c. of debris
18	"	River	3.92	12/20/30	1.2:0.12	12/21:12/23	14	13	92	14.5 cm. of Ceratophyllum
2	"	Well	5.88	12/22/30	0.8	12/27/30	13	4	30	35 c.c. of debris
The above were treated with arsenious oxide, C. P.										

*Species of Hydracarina: Limnesia historionica (Hermans): Hydrachina sp.: Cyclothric sp.

*Species of Hydracarina; Limnesia historionica (Hermans): Hydrachina sp.; Cyclothric sp.

TABLE NO. 7.

TOXICITY EXPERIMENTS WITH SODIUM ARSENITE ON MISCELLANEOUS ORGANISMS.

Culture No.	Kind of organism	No. per c.c. of culture before treatment	p.p.m. of As_2O_3 added p.p.m.	Date	Time	As_2O_3 present in subsequent analysis p.p.m.	Date	Time	No. per c.c. of culture after treatment No.	Date	Time	Nature of culture media
I	Spirogyra	Green tuffs	1.75	1/7/31	1:20 P.M.	0.839:0.3	1/9:1/13	10:00 A.M. 9:30 "				3% Knop's solution †
II	"	" "	0.0	"	"	0.0	" "	" "				3% Knop's solution ‡
I	Colpidium	16,100	3.5	1/10/31	2:10 P.M.	3.2 3.5	1/10 1/11	4:30 P.M. 2:00 "	20,440	1/11/31	2:10 P.M.	Hay infusion
II	"	9,972	0.0	"	"	0	"	" "	10,680	"	" "	" "
I	Paramecium	246	3.5	1/13/31	9:45 P.M.	4.48 2.48 .08	1/14 1/16 1/14	10:00 A.M. 9:45 " " "	744	1/16/31	9:30 A.M.	" "
II	"	232	0.0	"	"	0.0	1/16	" "	640	"	" "	" "
I	Stylonichia	292	3.5	1/13/31	"	4.48 2.48 .08	1/14 1/16 1/14	10:00 A.M. 9:45 " " "	2,672	"	" "	" "
II	"	222	0.0	"	"	0.0	1/16	" "	1,496	"	" "	" "
		No. per 500 c.c. of culture										
I	*Cyclops	2,016	3.5	1/14/31	11:15 A.M.	3.2 0.48 0.0	1/16 1/19 "	9:45 A.M. 9:20 " " "	600	1/19/31	2:25 P.M.	Culture of Banta for Daphnids. Science, N.S. Vol. 53, No. 1381, p. 557-558, June 17, 1921. Constituents: garden soil, horse manure, pond water.
II	"	2,016	0.0	"	"	0.0	"	" "	660	"	2:00 P.M.	
I	Nauplii	1,008	3.5	"	"	3.2 0.48 0.0	1/16 1/19	9:45 A.M. 9:20 "	12	"	2:25 P.M.	
II	"	1,008	0.0	"	"	0.0	"	" "	0	"	2:00 P.M.	

† Algae still producing oxygen (Alive); many chloroplasts irregular and contained few pyrenoids; many chloroplasts were collapsed and irregular.

‡ Algae (Alive) producing oxygen; chloroplasts regular and containing many pyrenoids. Spiral chloroplasts symetrical.

*This group includes the following species; Cyclops viridus (Jurine); Cyclops albidus (Jurine); Cyclops serrulatus (Fisher); C. bicuspidatus (Claus).

FISH CULTURAL SUCCESSES AND FAILURES IN MINNESOTA

THADDEUS SURBER

Superintendent of Fish Propagation

The geographical position and size of Minnesota with the sources of three mighty river systems located therein, combined with its immense area of lakes, is particularly favorable for fish life. The natural distribution of its fishes is therefore of more than passing interest because certain species peculiar to each of these three river systems are found within its borders.

The wall-eyed pike, our most important game and food fish, is peculiar to the Mississippi and Hudson Bay Drainage, but totally unknown in the Lake Superior Drainage. On the other hand the lake trout, often locally, but erroneously termed "land-locked salmon", is peculiar to the Hudosn Bay Drainage, only in rare instances having been taken in lakes tributary to the St. Lawrence Drainage, and totally unknown in lakes tributary to the Mississippi.

The brook trout, so far as we can learn, was restricted to the St. Lawrence Drainage and the smaller tributaries of the Mississippi south of St. Anthony Falls, and the St. Croix River. St. Anthony Falls, Minneapolis, was apparently a barrier to the ascent of the Mississippi River by trout.

The large Mississippi River cat and channel catfish were also barred by these falls but ascended the Minnesota River nearly to its source and are still found in considerable numbers along this entire stretch of water.

Preceding the craze which drained the northern and northwestern tiers of counties, hundreds of small streams in that territory maintained low summer temperatures through the medium of peat bogs. Drainage was far too effective in that territory with the natural result that forest fires have repeatedly burned over these bogs and cold swamps destroying hundreds of potential trout streams over an area several hundred square miles in extent. Notwithstanding this many streams still exist around the headwaters of the Mississippi, the tributaries of the Rainy River (which is a part of the Hudson Bay System), and even tributaries directly connected with the Red River of the North, which have been converted into excellent trout streams either for brook, brown or in certain cases, rainbow trout.

Where waters have become too warm for brook and brown trout we have succeeded in introducing rainbows. For many years it was impossible to obtain results with rainbow trout because they could not be induced to remain in the smaller streams but found their way downward until they either reached the Mississippi or Lake Superior, and there remained, but within the past six years we have been rearing rainbow trout, the original stock of which was procured from the State of Missouri, which actually remain in the smaller streams and we are now enjoying excellent fishing for these gamey trout over a large area in which no trout fishing ever before prevailed.

The expansion of brook trout fishing began nearly 20 years ago but over a period of years met with little success because fry alone were being planted in most waters. During the past eight years we have been introducing fingerlings exclusively, the area has been greatly extended and now brook trout streams are located in about 60% of the area of the state, in fact throughout the state except the southwestern prairie region, but our hope for the future so far as stream trout is concerned seems to lie with the rainbow trout and the Loch Leven, which are also thriving in streams which have for one reason or another become unsuitable for brook trout.

Most of our success in recent years can be attributed to the fact that we are planting, with our own trucks and our own men, directly to the streams and lakes, and therefore planting them in a manner which assures the minimum of loss. The most outstanding results, however, have been obtained through the introduction of wall-eyed pike fry into waters uninhabited by them at all. I have previously alluded to the fact that they were not found in lakes tributary to Lake Superior. Many of these lakes were over-abundantly supplied with natural food for game fishes but the only game fishes existing in their waters were too often found to be pickerel and perch exclusively.

The introduction of wall-eyed pike fry into such bodies of water met with almost instant success and the growth of these particular fishes in these lakes, notwithstanding the long protracted cold seasons, has been almost beyond belief, and has furthermore afforded us an opportunity to learn how fast wall-eyed pike can grow where food conditions are almost ideal. Four years after the introduction of wall-eyed pike fry into certain of these lakes they have been taken by hook and line weighing as much as four pounds, and six years after the

first planting occasionally specimens have been taken weighing as much as eight pounds.

The only reason that we do not, at this time, distribute wall-eyed pike in every lake in that territory is because of the inaccessibility of such lakes—the majority of them lie in a rough, unbroken wilderness without either roads or trails and therefore inaccessible for planting except along one line of logging road and a single highway. But some day that country will be opened up with roads leading to all the more important lakes and as soon as these are accessible we can be assured of wall-eyed pike fishing because the conditions conducive to success are there and only await the planting of the fry to be fruitful. Whenever I speak of the possibilities of success with wall-eyed pike I am accused of being over-enthusiastic, but I do not feel that this is a just conception of my attitude because of these very conditions.

In the southern part of the State, on the other hand, attempts to maintain pike fishing in the majority of lakes have not met with success. This has been due almost exclusively to the active competition of young carp for the food supply necessary for pike in the earlier stages of their growth and not by reason of the fact that the waters are otherwise unsuitable. This has been conclusively proven in certain cases where lakes have been dry over a period of a few years and then become refilled with water. In such lakes the introduction of pike fry always meets with success, but, of course, after they reach the second year of their growth in these lakes it is almost hopeless to expect results of any great consequence, until we also introduce suckers and minnows of various kinds to favor the growth of the pike.

In the attempted re-introduction of bass, crappie, etc., into these carp-infested lakes their maintenance is a rather forlorn hope, not only due to the competition for natural food previously referred to but also due to the fact that the spawning beds of these nest-building game fishes are destroyed, particularly those of the crappies and sunfish, by the hordes of carp which run into these shallow areas during their own spawning season and by weight of numbers alone destroy either the eggs or the newly hatched fry of both crappies and sunfish and any belated nests of bass also. Under these circumstances we are compelled to rear bass to fingerling size before introducing them into such lakes.

The successful operation, by our department, of a large pond owned by the Izaak Walton League in the vicinity of Minneapolis has demonstrated the possibilities (in large ponds

at least) of rearing a maximum of about 5,000 five-inch fingerling bass per acre.. Last year we constructed two bass ponds, one of eight acres, another of eleven, which in my belief is about the minimum size in which we can expect practical results, and the sites selected for these two ponds—Windom and Hutchinson—are in the heart of the carp infested lake region. While we in all probability shall never be able to maintain the maximum number required to provide good angling for bass in the many lakes demanding attention, at the same time if we do not neglect, through commercial seining operations, to remove the carp at the proper season of the year, namely, when they are running in to spawn, we shall in all probability, through these ponds, and a number of small ponds maintained by sportsmen's organizations, be able to provide reasonable fishing for bass for years to come.

About two years ago we practically completed the construction of a new trout hatchery in the extreme southern part of the state. This was found absolutely necessary due to the fact that three of the older hatcheries were facing a water famine. At this new hatchery we have an unvarying flow of approximately 10,000 gallons per minute of pure spring water of a temperature of 47°. This season the output of fingerling trout of various species will be approximately 2¼ million three to five inch fish. The hatchery has actually been in operation nearly five years and has clearly demonstrated that volume of flow is far more important in trout culture than either quality or low temperature because it is of sufficient volume to permit a gradual increase of the flow in both hatchery troughs and cement rearing ponds as the trout increase in size. This has had the effect of practically nullifying the hazard of disease and through the increased exercise afforded by the strong current both in hatchery troughs and in ponds, induced an exceedingly keen appetite among the growing fishes thereby producing marvelous growth.

At this new hatchery we have one dirt experimental pond planted with aquatic plants, principally water-cress, which produces a sufficient quantity of fresh-water shrimp to support several thousand trout maintained in it up to the yearling stage.

We have hatched at this place some lake trout which are thriving beyond all belief, the loss from actual disease having been absolutely nothing. These fish are now slightly over three years old and vary in length from eighteen to twenty-two inches, and while it is yet a problem as to whether they

are going to mature and produce eggs, the object of the experiment in their rearing, we sincerely hope we shall be able to accomplish this result because we are absolutely unable, owing to weather conditions existing during the spawning period of these fishes, to procure a natural supply of lake trout eggs for replenishing certain inland lakes which are becoming depleted.

A 4½ acre pond at this station, devoted to the cultivation of small-mouthed black bass, has been productive because of favorable conditions, particularly the vast quantity of shrimp growing in a natural state in this pond. While we have harvested a crop of small-mouthed bass from this pond but two seasons, the maximum last season being something over 12,000, the production is of unusual size, in my belief, because the fish removed from this pond in October average 5 inches in length.

Previous reference has been made to the wall-eyed pike as a food fish. It is classed as a food fish only when taken from international and interstate waters, except those taken at the commercial fisheries on Red Lake; in all other lakes and streams lying entirely within the boundaries of the state it is classified as a game fish. At the same time we must not lose sight of the fact that its importance as a food fish is not exceeded even by the whitefish because of the much wider distribution of the pike.

Outstanding results have been accomplished rather unexpectedly in the introduction of the so-called Labrador Whitefish from our largest inland lake (Red Lake) into waters of Lake Superior. We have for a period of about five years had a surplus of these whitfish eggs over and above what we could handle at our Red Lake Hatchery and this surplus has been transferred to and hatched at our Lake Superior Hatchery near Duluth, all the resulting fry being planted in Lake Superior. During the period from 1927 to 1931 inclusive approximately 84 million fry produced from that source have been planted in Lake Superior waters.

Notwithstanding ichthyologists are now prone to regard the Lake Superior whitefish as being identical with the Labrador whitefish, the fishermen of the North Shore of Lake Superior last fall readily identified the comparatively large run of whitefish appearing along their shore as being entirely different from any runs of previous years and as there is a decided difference in the size of the eggs obtained from the native whitefish of Lake Superior and those which we have been introducing in its waters we had no difficulty in dis-

tinguishing that difference when the eggs were delivered at our hatchery. Eggs of the true Lake Superior whitefish run about 35,000 to the quart whereas those obtained from the so-called Labrador whitefish of Red Lake approximate 52,740 per quart.

During the past fifteen or eighteen years commercial fishing for whitefish had been maintained at such a low ebb that we have had no laws regulating this fishery in Minnesota waters of Lake Superior, consequently, the sudden appearance of whitefish in large numbers during the fall of 1930, which was again repeated to a certain extent during the spring of 1931, found us without any legal means of meeting the situation. It is, however, gratifying from the fish cultural point of view to know that these fish within a period of about four years become matured and are now spawning, or at least spawned last season, in large numbers along the coast line of about 200 miles.

Until within recent years the pickerel or so-called Great Northern Pike has been held in but little esteem as a game fish and this belief still exists where it still abounds in the northern tier of counties. However, its ability to compete with the carp in carp infested lakes in the southern part of the state has won recognition in that section and more and more requests are made for restocking which we are meeting with more or less difficulty because we are not yet prepared to handle pickerel eggs as successfully as we do those of other species.

Discussion

MR. SURBER: We have not only found the rainbow taking well in the streams but so far they have apparently been immune to ordinary trout diseases, at least in our waters and in our hatcheries. In certain waters in the southeastern part of the state where they never had any trout but did have smallmouth bass we now have excellent rainbow fishing along with the smallmouth fishing.

MR. ROSS (Missouri): I noticed a statement in your paper that the streams had become too warm for brown trout, hence the introduction of rainbow. Is it true that the brown trout requires a lower temperature than the rainbow?

MR. THADDEUS SURBER: Absolutely. We have found that strain of rainbows in the Cannon river will stand midsummer temperature. We had an average temperature last summer of 82 or 83 degrees. We could never maintain in that stream any brown trout; we have planted thousands of them but could never maintain them—they either die or leave the stream, and it is not a natural tendency of brown trout to desert these streams because food is abundant. That is just one ex-

ample out of many. In our north shore country, where in the tributaries of Lake Superior we are supposed to have the most famous trout streams, we found a number of years ago that the midsummer temperature is too high to maintain trout of any kind except in certain small tributaries. That was due to the repeated forest fires which not only opened the entire country bordering on these streams but destroyed all the cold swamp cedars. In that territory we first introduced small-mouth bass in two very large streams, and we are having some success with them; but reports of fishermen and anglers this summer would indicate that the rainbows are taking in splendid manner.

MR. ROSS (Missouri): With reference to your statement that disease was limited by large volume of water; we have found in Missouri that we have no trouble with disease in rainbow trout if we have a sufficient volume of water. In our hatcheries in which the volume decreased last year we had some trouble with disease, but in the hatcheries where we have had a large volume of water there has been practically no loss from that cause. We discovered this year that in Cave Spring, at the headwaters of the Current river—contrary to the fish culturists—rainbow trout have propagated naturally. It is the first time that natural propagation has been discovered in the streams; all our trout have to be artificially propagated in Missouri, with this exception. I am inclined to think that these fish in Missouri have been there for probably twenty years and that they are acclimatizing themselves to the warmer water. That water has a temperature of about 54°; it varies only two degrees winter and summer, and does not freeze.

MR. THADDEUS SURBER: With regard to the period of time during which you probably have had rainbow trout in Missouri, in 1896 in southwestern Missouri I had the pleasure of catching the first rainbow trout I ever saw, so I imagine you have had the same strain of rainbow trout in Missouri longer than you imagine.

MR. ROSS: For about fifty years.

MR. THOMAS (Missouri): Rainbow trout have been in our state since 1880, or before that.

A SUCCESSFUL FISHWAY

B. O. WEBSTER

Wisconsin State Conservation Commission

Unless it be water pollution, there is probably no other one factor which has done so much to deplete the numbers of game fish in American waters as the construction of innumerable dams across the thousands of rivers and streams of North America. Any obstruction in a river or stream which interferes with the migration of fish at spawning time has a most detrimental effect upon natural reproduction. If fish can not find the best spawning ground for which they search in the headwaters of rivers and streams, they must deposit their spawn under less favorable circumstances.

Under the best of circumstances the number of eggs which ultimately produce mature fish is very low, and any lessening of the favorable circumstances practically results in no natural reproduction. This is the situation as it exists in water courses whose natural uninterrupted flow has been obstructed by dams.

Some people claim, particularly those who are interested in belittling the detrimental effects of dams on natural reproduction, that artificial propagation counteracts the injury done. But to those of us interested in fisheries work, artificial propagation is never and should never be considered as replacing natural reproduction. At the best, artificial reproduction only supplements natural reproduction.

The damage done to reproduction by dams in streams has been realized in varying degrees for many generations. But, except in coastal rivers where commercial species only are affected, little has ever been done to counteract the damage until the last two or three decades. There are two reasons for this lack of attention in inland waterways; first, that it is only in the past few decades that the numbers of fish have seriously declined; and second, that it is in the last two decades that the numbers of dams across streams have increased so materially.

Almost without exception, the fishways which have been tried, and the few which have been found successful for commercial species, principally salmon in coastal rivers, have been of the fish wheel or fish ladder type. When the problem of providing means of access over dams for inland water species became acute, attempts were made to adapt the fish wheel or fish ladder type of fishway to these inland rivers. All such attempts failed.

Of the inland water species of fish, the only one which could adapt itself in any measure to the ladder type of fishway was the trout. But the power dams across inland water streams almost invariably were built on streams larger than trout streams, which meant that the trout was not affected as much as other species.

In the north central part of the United States, and particularly in the Lake States, this problem has become very important. The species of fish most directly concerned are the wall-eyed pike or pike perch, the pickerel or great northern pike, the bass, and in Wisconsin, the muskellunge and sturgeon. None of these species will use any type of fishway that requires leaping as does the fish ladder type; also, each of these species is entirely too cautious and wary a fish to enter any fish wheel. Consequently up to the present time all attempts to provide access through or over dams for these fish have failed.

For more than 25 years the division of fisheries of the Wisconsin Conservation Commission has been experimenting with every type of fishway that seemed practicable. Intensive experimentation began in the three year period 1907-1908-1909. At this time experimental fishways were placed in dams across several Wisconsin rivers. Everything was done to make fair tests and to try to devise a successful fishway. A careful check was made and accurate records were kept of all fish that went through each of the fishways. Hoop nets were placed at the upper outlet so that no fish could go through without being seen and recorded.

The first major experiment was conducted in the spring of 1909. A fishway of the ladder type was installed in a dam on the Wolf river near Weyauwega, Wisconsin, and close observations were made every day from April 16 to June 15. During this entire two month period only seven suckers negotiated the fishway successfully. In 1912, further experiments were made. The fishways installed at this time were also of the ladder type, but varied somewhat in detail from the earlier unsuccessful one. In the 1912 experiment fishways were placed in the dam on the St. Croix river at St. Croix Falls, the Kilbourn dam on the Wisconsin river, the Eureka dam on the Fox river, and again in the Weyauwega dam on the Wolf. As in the earlier experiment, hoop nets were placed and daily records were taken. This time the observations continued throughout the month of May.

At St. Croix Falls not a single fish, either game fish or rough fish, went through the fishway. One sucker went

through the fishway at Kilbourn, and at Eureka there were two bass, three pickerel, two suckers, one carp, 13 dogfish, and one sunfish. At Weyauwega only suckers, 49 of them, went through.

None of these early fishways could be called successful in the least. Since 1912, the fisheries division has been experimenting with every type of fishway that seemed practicable. However, none of them, until 1931, showed any promise of being satisfactory.

As well as carrying on experiments in the state of Wisconsin, the fisheries division through all this time has kept in close contact with fish commissions of other states, the federal government, and Canada.

Within the past year the fisheries division has corresponded with every organization, either official or unofficial, which was in a position to be informed on late developments in fishways. Eminent authorities throughout the country were asked their opinions about various types, and questionaires were sent to every source from which emanated reports of successful fishways.

Invariably the response was the same. Men interested in fish culture all realized the imperative need of a successful fishway, but no one had anything constructive to offer. Newspaper stories claimed that there were successful fishways in certain states. However, direct requests for information and records to these places proved fruitless as no records had been kept, which meant there was no way to prove the value of any fishway.

Late in the summer of 1930, another rumor of a successful type of fishway came to the attention of the fisheries division. This one was not of a fishway in operation, but rather of a plan or miniature designed, invented, and patented by Harry Barr of Ironwood, Michigan. Steps were taken to communicate with Mr. Barr and through the interest and co-operation of many individuals and agencies, a new experiment was made. Mr. Barr was so sincerely confident of his fishway that he paid the costs of installation himself. Local citizens living in the western part of Vilas county, Wisconsin, the Wisconsin Railroad Commission, the Chippewa and Flambeau Improvement Company, the Wisconsin Highway Commission, and the Wisconsin Conservation Commission all cooperated to make this final test. The Rest lake dam in the Manitowish river was chosen as the site for the experiment. There were many advantages and many disadvantages to this site. Among the advantages were the fact that the Rest lake

dam is the furthest one upstream in the Manitowish river which means that it obstructed the passage of fish just before they reached their spawning ground; the Rest lake dam is not a power dam in itself, but a control dam regulating the water level of seven connected lakes; the Manitowish river and the lakes above are all well stocked with fish.

Among the disadvantages of the experiment were: (1) the company which owned the dam did not feel that they could risk the possibility of endangering the dam by constructing the fishway where it should have been constructed, i. e. immediately adjacent to the dam at the highest point upstream in the river; (2) the Rest lake dam is built underneath a highway bridge on U. S. 51, which means a large number of sightseers which could not help but act as a deterrent to fish entering the fishway; and (3) construction delays meant that the fish lock could not be finished until late in the spring after the fish had finished their running season.

Radically different in type from any fishway suggested before, the Barr type is really a fish lock or fish elevator rather than a ladder or wheel. In operation it is quite similar to the locks which elevate boats from one level to another. As installed at the Rest lake dam, the Barr fish lock consists of a large concrete box with a concrete floor, inlet and outlet valves, an egress tube, and an automatic counter-balance tripping device. The outlet for water and inlet for fish are at the bottom of the river bed. Fish pass out from the fishway through a 24 inch pipe from the box to the lake. This pipe is 40 feet long and extends entirely through the right-of-way of the road. Its extreme length is another reason that would tend to prevent fish from going through. If the fish lock could have been placed where it should have been placed, there would have been no necessity for such a long egress tube.

The lock is extremely simple in operation. It is filled by means of an inlet tube from the lake above to the bottom of the concrete box. Water enters the box at considerable pressure which results in a constant swirling, which is an attraction to the fish.

The fish are first attracted to the entrance of the fish lock by the great rush of water which results from the emptying of the box. After they pass through the inlet, the swirling of water about in the box acts as a further attraction. In the corner of the box immediately below the entrance to the egress tube, there is a break in the wall which slants down

from the lake level more than halfway to the bottom of the box. As the fish swim around in the box following the current of the swirling water, they find this opening. The second or third time they go around they again find the opening and by this time the water is high enough so that the automatic trap has opened and they can pass out through the egress tube.

The entire operation of a fish lock is automatic. The tripping device on the back which is on the counter-balance principle and regulated by a flow of water through valves into iron boxes suspended on a pivot, can be set at different time intervals. During the record taking this spring the fish lock operated at 40 minute intervals.

After the filling interval has passed, the lock empties, and the water rushes out into the river channel below, attracting the fish. They enter through the opening at the bottom, the lock fills, and the operation continues.

The best test of a fish lock, or of anything else, is found in the answer to the question—does it work? The Barr fishway installed at the Rest lake dam last spring did work, and is still working in spite of the many disadvantages with regard to the location and the lateness of construction. It worked so well that the Wisconsin Conservation Commission, which has been made skeptical of all fishways, adopted a very commendatory statement about it at a meeting held July 25, 1931:

> "Complete investigation and careful checking over a period of two months has convinced the commission that the Barr fishway now in operation at the Rest lake dam on the Manitowish river fulfills its purpose. It is the best means yet devised to permit the passage of fish from the lower to the upper side of dams.
>
> "This commission is intensely interested in providing suitable fishways wherever they will benefit fish life. The Barr fishway appears to be entirely satisfactory, and the conservation commission recommends that fishways of the Barr type be installed in all dams in Wisconsin where it is considered that such installation would be beneficial to fish life and practicable."

This is the first public announcement which has been made of the success of the Barr fishway at Rest lake dam. But even though there has been no public announcement, fisheries authorities of several states have heard of it and are making investigations. All such fisheries authorities who have seen the Barr fishway, speak of it in the most commendatory terms. For instance, A. B. Cook, Jr., field superintendent of the fish

division of the Michigan Department of Conservation, wrote as follows to Mr. Barr, the inventor:

> "The device you have invented was given a very thorough inspection and we were able to observe all the stages of its operations. Frankly, I believe you have devised the only practical method for successfully elevating fish to higher levels in streams obstructed by dams."

In making observations of the Barr fishway last spring, the fisheries division of the Wisconsin Conservation Commission made just as detailed records as it had of the earlier unsuccessful fishways. A hoop net was placed so that it completely covered the outlet of the egress tube and no fish could go through the tube without being caught in the net and no fish that did not go through the tube could possibly be caught.

In the tabular records taken during the month in which the observations were made, from May 19 through June 18, and with the exception of June 3, on which day no records were kept, there was a total of 1,181 fish that went through. These included 399 pike, 173 bass, 552 suckers, six lawyers, 32 muskellunge, and 19 sunfish. These totals are all the more convincing when it is considered that the running season for all species considered was at an end before the fish lock was put in operation. Daily records were kept and tabulated. The table shows just how many fish of each species went through the fishway each day.

The question might be raised that while the Barr fishway has proved unquestionably successful at the Rest lake dam in Vilas county, Wisconsin, would it be successful on a larger dam? The Rest lake dam is comparatively small, having a total drop of less than 12 feet. However, there is no reason to believe that the Barr fishway modified to meet changes of circumstances would not work on any dam regardless of height. It could be modified by increasing the single box or lock to the required height, or by having a series of locks. The total difference in height between the level of the river below and the level of the lake or flowage above the dam is not a particularly significant factor as there can be more or fewer locks depending upon the differential.

It is interesting to conjecture the ultimate significance of a successful fishway. Its tremendous importance in making possible more efficient natural reproduction is paramount. In addition to this, however, there are other factors which will become increasingly more important in fisheries work as more and more Barr fishways are put in operation. It will help

in securing spawners for artificial propagation work; it will be of great assistance in regulating the proportion of rough fish and game fish in waters; it will also tend to relieve temptation to violation in those places below dams where game fish congregate in large numbers.

Most states have statutes or have empowered public service commissions or conservation commissions to compel the construction of fishways in all dams. These laws have not been enforced, and wisely so, because to date there has never been a successful type of fishway. Administration of the laws, therefore, would have meant a futile waste of money. But with a proven successful fishway available, these laws should be enforced. Undoubtedly, power companies and others responsible for the construction of dams, will be glad to cooperate.

As the science of fisheries progresses, one after another of the one-time seemingly insurmountable obstacles are overcome. It is my firm belief that this Barr fishway is the most important contribution to the inland water game fisheries program that has been made in the past 25 years.

Discussion

CAPTAIN CULLER: When you conducted that experiment was the normal spring flow going over the dam? Wasn't the water much lower this spring than it has been in the past?

MR. WEBSTER: There was a very nice flow of water going over the dam during the whole experiment. Naturally the water was low this spring, and there is a possibility that there was not as much water going over the dam at that time as there would be in the high water period. But there was a much greater volume of water going over the balance of the dam than ever went through the fishway. In making my inspection of the dam and looking it over carefully, the amazing thing about it is that the fish ever went into the fishway, with the great quantity of water going down on the other side of the river.

CAPTAIN CULLER: Take the case of the Winter dam; as I recall it, there is an apron in the falls? If that apron were not there and you had an average level below the dam such as you have in the majority of the streams with large bodies of water, wouldn't the fish go by the fishway and run up towards the dam?

MR. WEBSTER: I do not see why they did not go by when the experiment was going on, on account of the large volume of water coming down on the other side. But you will remember that this fishway was not located in the dam where it should be located. As I stated in the paper, the power company objected to the establishment of this fishway

against the slashboard, as should have been done, consequently it was put off to one side of the dam, which meant that it was very much to one side of the river. I think the number of fish that went through it, in spite of its being incorrectly placed, was beyond anything I have ever known.

CAPTAIN CULLER: That is what I was trying to get at—that the correct place for the fishway would be in the dam proper, and the slowing up of the current on both sides would possibly induce the fish to go into the slower current rather than into the heavier current at the foot of the dam.

MR. WEBSTER: Yes, I would say it would. Of course this fishway could easily be properly placed in the dam at the time of construction. At the Winter dam which you just mentioned, which is a very high dam, preparations are being made to install it and one of the power men told me that on account of the dam being already constructed, and its height, the cost of building the fishway would be about $14,000. It cost Mr. Barr $2,900 to build this one. He furnished that money himself to build the fishway, because he had so much faith in it.

PRESIDENT LECOMPTE: You would not recommend that fishway for an 85 or 90 foot dam?

MR. WEBSTER: I would recommend it for a 120 foot dam or any size dam whatsoever, if fish congregate at the foot of the dam during the spring time. It can be built to conduct the fish over any size dam at all.

PRESIDENT LECOMPTE: Hydraulic power companies are building dams running anywhere from 85 to 130 or 140 feet high, and they are paying the state a certain amount for the propagation of fish. In one case where a dam 90 feet high had been constructed, the power company paid the state $4,000 for this purpose instead of putting in a fishway. They have not yet found a fishway, nor have I which would be adequate to take the fish over such a dam, and I was wondering if your opinion would be favorable to the use of such a fishway as you have described where the dams are as high as those to which I have referred.

MR. WEBSTER: I think the engineers could work out a plan to establish this fishway and have it operate successfully on any dam where fish congregate below the dam.

MR. THADDEUS SURBER: This fishway cost approximately $250 per foot height, did it not?

MR. WEBSTER: I have not figured it out—about $3,000, yes.

MR. THADDEUS SURBER: Have you made any estimate as to the increased or decreased cost of construction for additional height?

MR. WEBSTER: No.

MR. THADDEUS SURBER: Wouldn't the cost for a high dam amount to an almost prohibitive figure?

Mr. Webster: I do not think so—not if the fishway were installed at the time the dam was built. I understand that this fishway I have described could have been installed in the dam for less than a thousand dollars if it had been put in at the time of construction of the dam.

Mr. Ross (Missouri): What volume of water is required for this fishway on a twelve foot dam?

Mr. Webster: There is an eight inch pipe going over the lake into the fishway, and when the automatic gate closes and the fish are inside the fishway there is a fall of about twelve feet, creating a considerable amount of swirl in the fishway. As the swirl becomes less the fish simply follow the current of water right up until they see this egress pipe and pass out. Up to the time that the outside gate automatically closes, the water that the fish are in is quiet. The hole in the fishway is below the surface of the river. When they swim in they go down into the hole, and when it commences to fill there is a violent swirl in it, until it fills up, and as the swirl becomes less the curiosity of the fish brings it to the surface and sends it out the egress pipe. It is a very remarkable and very wonderful thing.

Mr. Viosca: There is a question in my mind as to whether it is desirable in every case for pond fishes to climb into impounded waters above a dam. I made quite a number of observations on the Ouachita river just below the Arkansas border, where there are several dams, and it appears to me that the fish are accumulating there to catch the shiners and small fish that are coming over the dam and are therefore feeding and not migrating upstream for the purpose of spawning. We had one experience in that connection which might be of interest. A lumber company on the Calcasieu river erected a dam, and in the waters they were damming off there was the pseudaplites bass which was described yesterday. The fishermen always noticed great numbers of fish accumulated below the dam, and believed they were endeavoring to get above into the impounded waters. We found that the dam created excellent spawning conditions in the upper Calcasieu river. There were slack water areas where the fish could spawn, and the fish were always abundant in that section of the stream. The citizens of Oakdale, Louisiana, when the company abandoned the mill, blew up the dam with dynamite. I understand—and I made observations of my own—that the pseudaplites bass is greatly reduced in number since the dynamiting of this dam, even though they then had the privilege of swimming up stream. So that there is another side to it, and I think we ought to have investigations in cases of this kind to find out whether it is really necessary for these pond fish to get into another reach of

the stream, and whether they are trying to get up there or not. I do not believe all fish which accumulate below dams are trying to get up into the water above.

MR. WEBSTER: A thorough investigation should be made before the construction of a fishway in a dam is recommended. A promiscuous order for the construction of fishways in all the dams in Wisconsin will never be issued. There are about eight hundred dams in our state, and we would not by any manner of means recommend a fishway in a dam on the Wisconsin river that was going to conduct all the carp out of the lower part of the river into the reservoir dam up above.

MR. COOK (Michigan): There is one point that perhaps Mr. Webster did not amplify sufficiently, and that is the main reason why the power companies object to the establishment of fish ladders or fishways in their various dams. It is not the matter of initial cost, that Mr. Surber brought up, because many of the big power companies of our state do not object to going to almost any amount of trouble and expense to establish fish ladders, so-called, in the dams. To them the most important consideration is the waste of water, which of course, means money to the power companies, during certain times of the year. One of the important features of this Barr fishway, in my judgment, is that it can be so adjusted that it will operate only once in twenty-four or possibly once in forty-eight hours during the time of year that there is a small concentration of fish. The fact is that this fishway is operating under conditions which are far from favorable, and that Mr. Barr has installed it at a cost much in excess of what it should have been. To make my point clear, may I say that the walls of this dam—I measured them—are only ten inches in thickness, and the power company demanded that he put sixteen inch walls in this box that he built, the only reason being, so far as I can see, to make the matter more difficult for the gentleman in question. Another point that should be mentioned is this: the day I was there, fish so small in size that they could readily get through the mesh that Mr. Webster had placed in his trap above the dam were in evidence both in the trap itself and in the fishway, indicating that very small fish could make the ascent. Personally I was much impressed, and I made three trips to this location at various times to observe the action of the fishway which Mr. Webster has described.

MR. EUGENE SURBER: Have any attempts been made to lead the fish to this fishway, say by putting in a cross screen, or screen of any kind? The idea I have in mind is that you might put in leads from either bank of the river, leading up to the fishway, thus increasing the probability of the fish finding the inlet more quickly.

Mr. Webster: Perhaps you noticed one of the pictures which showed the area below the dam where there were a lot of logs, being the remains of the old logging company's dam. They had a long sluiceway below this dam where they used to run their logs through, and no effort was made to get the fish to go to the fishway, except that of digging out a small channel underneath the logs directly opposite where the outflow of water of the fishway came. That is one reason why I am so much impressed by this fishway—how the fish found it in the first place was the amazing thing to me. As I say, no particular effort was made in that direction except to dig out a little channel in the creek, which was constantly dug out a little more as the water ran out of the fishway.

THE FEDERAL BLACK BASS LAW

TALBOTT DENMEAD

Law Enforcement Officer, U. S. Bureau of Fisheries

The cry "Something must be done for the Black Bass" was answered by Senator Harry B. Hawes when he introduced a Bill in Congress regulating the interstate transportation of Black Bass. This Bill was fashioned after the original Lacey Act to regulate the interstate transportation of wild animals, which first passed Congress in 1900, but which lacked certain important features and was amended in 1909. The success of the Lacey Act as a conservation measure is too well known to dwell on at this time; suffice it to say, it did yeoman service until that part relating to birds was superseded by the Migratory Bird Treaty Act in 1918. Since then it has been most successful in protecting our valuable fur animals, especially the beaver.

In 1926 the original, but defective, Federal Black Bass Law was enacted. As no government agency was directly charged with its enforcement and no appropriation was made available, it remained dormant until re-enacted with amendments in 1930, and the enforcement placed in the hands of the Department of Commerce. Its passage occurred too late in the session to secure an appropriation. On March 1, 1931, the sum of $6,075 became available for the enforcement of the law for the balance of the fiscal year ending June 30th, 1931. The Bureau of Fisheries, the government agency directly responsible for the enforcement of this law immediately organized a Law Enforcement Unit and secured the appointment of a law enforcement officer to take charge of the work.

On July 1, 1931, an appropriation of $20,000 became available with which sum the Bureau is prepared, in cooperation with the State game officials, to enforce this most important national fish law in 48 states. The law as it now stands is all that its proponents desire, and no essential amendments are necessary to accomplish the purposes for which the law was intended, namely, to give further protection to the black bass, although many think the law should be made to cover all game fish.

Section 2, which is the very heart of the law, is here quoted in full:

"Sec. 2: It shall be unlawful for any person to deliver or knowingly receive for transportation, or knowingly to transport, by any means whatsoever, from any State, Territory, or the District of Columbia, to or through any other State, Territory, or the District of Columbia, or to or through any foreign county, any large-mouth black bass (Micropterus salmoides) or any small-mouth black bass (Micropterus dolomieu), if (1) such transportation is contrary to the law of the State, Territory, or the District of Columbia, from which such black bass is or is to be transported, or (2) such black bass has been either caught, killed, taken, sold, purchased, possesed, or transported, at any time, contrary to the law of the State, Territory, or the District of Columbia, in which it was caught, killed, taken, sold, purchased, or possessed, or from which it was transported; and no person shall knowingly purchase or receive any such black bass which has been transported in violation of the provisions of this Act; nor shall any person receiving any shipment of black bass transported in interstate commerce make any false record or render a false account of the contents of such shipment."

In the simplest words possible, the Federal Black Bass law prohibits the transportation of fresh-water largemouth and smallmouth black bass from one state to another that have been taken, sold, transported or possessed in violation of some existing state law. That is, a violation is predicted on an infraction of a state law, coupled with an interstate transportation.

In no section is there any attempt made to interfere with the state's privilege to do what it pleases with the black bass taken within its confines, unless it is in Section 3, which requires that any package or container, which contains black bass, shipped out of the state, must be clearly and conspicuously marked on the outside, where all can see, with the name "Black Bass," and an accurate statement of the number of such fish contained therein, and the names and addresses of the shipper and consignee. In this section the word "shipped" is used and not "transported", and it does not appear that this section applies to black bass carried out by the non-resident licensed angler. In fact, it is evidence that this act is aimed principally at illegal commercial fishing. The angler however, is liable to arrest and prosecution and his bass to seizure if he captures the fish illegally and carries them interstate.

If, after warning, commercial fishermen persist in shipping black bass from "open" states into "closed" territory, and fail to properly mark the shipments, the provisions of the section just referred to will be strictly enforced. In this manner, profits will be taken from the bootlegging of bass and indirectly the bass of those states where they are afforded little or no protection by state law eventually will be kept from the markets.

In order to secure effective cooperation with the Federal Government in the enforcement of the law regulating interstate transportation of black bass, a state should have laws: (1) prohibiting the sale of black bass at all times, whether taken within or without the state; (2) providing a close season entirely covering the spawning period; (3) prohibiting the export of black bass, except that licensees may transport a reasonable number, for example two days limit; (4) providing a limit in size from tip to tip, which size should be as uniform as possible; (5) providing a daily limit.

Nine states have no state-wide close seasons on black bass. We all know the habits of these fish in guarding the nest, eggs, and young, and the ease with which they can be taken from the nest by almost any fishing device. Certainly this great game fish is entitled to every assistance and protection during the reproduction period, yet nine of our greatest black bass states allow these fish to be taken 365 days a year, unless fishing on Sunday is prohibited, in which case the rest day is not for the fish but for the fishermen.

More than half the states now have laws absolutely prohibiting the sale of black bass regardless of where taken; a majority now have a size limit of nine inches or over, with a ten-inch limit appearing to be the most popular. Eleven states have no size limit, six have no daily limit, and one has no fishing license, not even for non-residents. There are 15 states which legally permit the sale of bass taken outside the state and brought in, which at the same time prohibit the sale of "native" or locally caught fish. It is respectfully submitted that this is a short-sighted policy on the part of these states and leaves the door open for illegal selling of black bass actually, and generally illegally, caught within the state. It encourages bootlegging.

The following are the states allowing the sale of imported black bass while prohibiting the sale of fish taken within the state limits: Rhode Island, Massachusetts, Delaware, West Virginia, Michigan, Indiana, Missouri, North Dakota, South Dakota, Kansas, Colorado, Wyoming, Utah, New Mexico and Oregon. The state of Pennsylvania which previously occupied a conspicuous position in this class on account of the large bass markets in its pricipal cities enacted a law at the 1931 legislative session prohibiting the sale of black bass in that state at all times, regardless of where taken. The figures quoted have been most carefully checked with the available laws of the various states, and are believed to be correct, but

if there are any errors due to recently enacted laws, or for other reasons, the Bureau wishes to be informed.

The work of the newly created Law Enforcement Division of the U. S. Bureau of Fisheries already has extended beyond merely the enforcement of the Federal Black Bass Law for which it was organized. The correspondence covers a multitude of matters relating to angling, and our opinion is asked on many subjects connected with fish and fishing. As an example of the kinds of questions propounded, we were recently asked to give an opinion on whether bass bugs are artificial flies; this is important as several states, notably Maine and New Hampshire, which have open seasons when it is legal to fish only with flies. We are asked to arbitrate disputes relative to the use of fishing licenses in water dividing two states; also matters pertaining to pollution are referred to us for attention.

The Federal Black Bass Law covers no fish except largemouth and smallmouth black bass. Numerous reports of violations have been reported and investigated where the fish involved were other than these two species. In some cases investigated, it was found that there was no violation of the Federal statute, and in others that a violation of state law, necessary to form the basis of a federal prosecution, could not be proved, and in a few the acts complained of were clearly a violation of the law of the state from which the complaint came, and could be successfully prosecuted in the State Courts.

Among the important features of the law, not already referred to, are the right to seize fish illegally transported, purchased or received, in violation of the Act or any regulation promulgated thereunder, which fish are forfeited upon conviction as part of the penalty; or if the court believes the law has been violated, they may be declared forfeited without any conviction.

Black bass transported into a state for use or storage therein are subject to the laws of the state, as if such fish had been taken in that state, and are not exempt therefrom by reason of being introduced in original packages. Fish dealers are not compelled to keep records, but if they do so, are liable for making any false record. The law is enforced by employees of the Department of Commerce authorized to do so, and by no others. Federal and State Game and Fish protectors have no authority to enforce the law unless special authority is conferred upon them. The penalty for a violation of the Act is a fine of not over $200 or imprisonment for not over three months, or both.

PRINCIPLES OF BULLFROG (*RANA CATESBIANA*) CULTURE

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Although many attempts at frog culture have been undertaken in various parts of the United States during the last half century, very few, if any, of these efforts have been rewarded with success. The United States Bureau of Fisheries, in its "Memorandum on Frog Culture", attributes these failures first, to the inexperience of the operators, and second to the fact that the capital invested was not sufficient to carry them over the first few experimental years.

Even those experimentors who had acquired a thorough knowledge of their habits and habitat requirements, encountered one serious difficulty, that of providing an adequate supply of food for the adults. As frogs eat only live food, the difficulty increases with the size of the frogs, and with the largest bullfrogs, which species is most in demand on the commercial markets, this problem became insurmountable even in many projects which had overcome most other difficulties.

The author of this paper has made an intimate life study of Louisiana frogs in their natural state, and became interested in the culture of the commercial species about fifteen years ago. Fostered by the Southern Biological Supply Co., Inc., experimental work was begun in 1917, and is still in progress at this time. There is yet much work to be done, and I do not wish to issue prematurely the results of unfinished experiments but pending the continuation of our experiments these pages will at least reveal the line of thought I have been following.

Difficulties Encountered. It is due to the fact that the frog presents two entirely different stages in its development, that the problem before us is far more complicated than fish culture. Tadpole culture in itself is hardly more difficult than carp culture, and most frog farmers are successful in rearing them through this stage. The frogs themselves, however, are greedy, predatory creatures which must have a copious supply of live food, and often resort to cannibalism. Thus we come face to face with two interrelated difficult problems standing in the way of success, the providing of this food supply and the suppression of cannibalism or turning it to a useful purpose.

Habitat. The bullfrog's natural habitat is in or near any fresh water pond, marsh or swamp which does not dry up during a summer of normal rainfall. They are sometimes found along streams or lakes, but there they are usually kept under control by predaceous fish such as bass and pickerel which devour their tadpoles and young. Only in the shallow marshy pockets of lakes and streams can their tadpoles survive to any extent. In button-bush, tupelo or cypress swamps, and in cattail or bullrush marshes, they are found in greatest numbers. In such places their food is abundant, and their tadpoles and young can survive by hiding amongst the vegetation. Such places are also subject to an occasional drying out during a severe drouth, and their natural enemies, such as water snakes and fish are either thinned out or exterminated during such periods. Shade is the essense of their habitat and where there are no trees, such a willow, buttonbush, cypress or tupelo, we may find them amongst cattails, bullrushes, saw grass, pickerel weeds, arrowheads, or even lotus or water lilies.

Feeding. The growing frogs, and the adults, when feeding, spend the greater part of their time at the water's edge from which position they can jump at the moving organisms upon which they feed. They will eat only living organisms which they swallow whole. They prey chiefly on crayfish, water bugs, beetles, small fish, small frogs, tadpoles and any of the small creatures generally found in ponds and swamps. They will take butterflies, dragonflies and other insects on the wing if opportunity presents. The largest bullfrogs prefer insects, fish and crayfish measuring from one to three inches long, and seldom leap at anything under one-half inch. As they cannot stand dry heat, their habits are chiefly nocturnal, especially during the summer. While they may be hiding amongst the vegetation of the pond during the day, they are always active at night on the bank, except of course during the mating and hiberating periods.

Voice. In any particular locality, the bullfrog is usually the last *Rana* to emerge from hibernation. Specimens may be first noticed in their native haunts on any warm days from January along the Gulf Coast, until May or June in the northern states. Their sonorous bass voice, a bellow resembling that of their namesake the bull, is at first heard from single individuals, usually a few weeks after they appear from hibernation. Later the males, the only sex which sings, congregate in choruses, the chorus stage being reached in the gulf states by March or April, and in the north by June.

The choruses may be heard over a period of a month or more, being longer in the far south.

Egg Laying. The females, when ready to lay, congregate about the singing males and clasping occurs. The eggs are fertilized externally in the water as they pass out of the vent of the female. If not disturbed, they float in a thin sheet at the surface of the water, amongst brush or vegetation. A batch from a single female may cover from 5 to 10 square feet and contains from 10,000 to 25,000 eggs. Egg laying usually begins in April in the Gulf states and in May or June further north. It reaches its height in May and June in the south and in July in the north.

The rate of growth of the bullfrog tadpole differs considerably throughout its range. In Louisiana and adjacent states it never takes more than a year to transform into a frog, whereas part of the crop may transform in five or six months. In the north, two years may elapse before transformation. This is due to the fact that in the south the growing season is two to three times as long. In the gulf states, a proportion of the tadpole crop usually transforms at about 6 months old in the fall, the balance remaining in the water until the following spring and transforming at about one year. According to Wright,* two winters are passed in the tadpole stage in the north and they transform during the third summer at the age of 2 years or over.

The young bullfrogs feed chiefly upon insect life such as is usually found in the shallow water near shore, or upon the damp shore-line, or amongst aquatic vegetation. They will snap at anything living in sight if it is not too large for them. Growth may or may not be rapid depending upon the climate and the food supply. The writer has reared frogs from the transformation stage to mature size in two years, whereas in the north, due to the shorter growing season, it would take longer. It is difficult to tell how fast they grow in the wild state.

The Frog Ranch. Where ranching rather than more intensive cultivation is to be followed, the best rule is to imitate a natural swamp, pond or marsh lagoon in which bullfrogs are known to thrive, keep game fish, snakes and other enemies out, and propagate and encourage food forms such as crayfish, minnows, water bugs, greenfrogs, etc.

Since bullfrogs thrive naturally in the extensive rice fields of Louisiana in spite of the fact that most of the tadpoles are destroped when the fields are drained to harvest the rice, I

*North American Anura, Carnegie Inst. Wash. 1914.

would suggest that the system of irrigation used in the rice farming be followed wherever open range frog ranching is desired. No fences will be necessary and the crop can be gathered in the usual way by shining at night. Muskrats also thirve in the rice fields, so that such a project may be tied in with muskrat ranching.

The major difference between such a ranch and a rice field would be that in the frog ranch, more levees or hills and furrows should be provided to increase the frog producing capacity of tne project. This will also increase muskrat production. The hills should run in a north-south direction to produce maximum shade when planted in willows or other shade trees. These nills should reach at least a few inches above the maximum water level and the furrows or ditches should not be deeper than is necessary to protect the frogs or tadpoles from the heat in summer or from freezing during the hibernating period during the winter. Much shallow water 2 to 6 inches in depth is essential as their food thrives best and they catch it easier in shallow water. If sufficient shade is provided, a maximum depth of 12 to 18 inches in the ditches is deep enough in the southern portion of the United States. In colder climates, at least part of the area, or preferably a trench surrounding each unit area should be deeper than the greatest depth of the winter ice sheet. The frogs will seek the deepest water during hibernation.

In order to protect the tadpoles, the project must not be drained annually as is done in rice culture, except in the south where there is an annual tadpole crop, then it should be drained to remove natural enemies and refertilized after the tadpoles transform in the spring or summer. In the north it is a good plan to arrange for draining section by section alternately each year after transformation takes place. Lowering the water level also facilitates gatherings the frogs along the ditch banks.

Intensive Frog Culture. By far the most intensive frog culture yet worked out is that evolved by the Japanese. In that country, where land is at a premium and labor cheap it works quite satisfactorily. Small ponds are constructed, varying usually from 10 ft. by 10 ft. to 25 ft. x 25 ft. The fencing is placed on the levees separating the ponds. As little as 2 or 3 square feet of space is allowed to each large frog and less proportionately for the young. The different sizes of course are separated to prevent cannibalism.

The tadpoles are fed chiefly on boiled potato, the cheapest product available, and the diet varied occasionally with raw

fish or fish dressing to give it balance. Other animal dressings or garbage is used when available. The baby frogs are fed almost entirely upon live maggots.

For the medium and large frogs several items are resorted to. A small land crab, with habits similar to our crayfish, is secured in numbers and is most satisfactory food where available. Some have imported and are cultivating the Louisiana swamp crayfish (*Cambarus clarkii*). Small minnows and goldfish are easily obtainable. As it is difficult for the frogs to catch these in the ponds, elongated wooden trays are prepared and anchored at the edge of the water. Small cracks are left for the water to seep in, and they are made to float while holding about one-half inch of water. Quantities of small live fish are placed in the trays where they can easily be caught by the frogs. I have suggested that each tray be braced between a raft of four substantial logs. The frogs like to climb out on these logs, which at the same time prevent the minnows from escaping.

Another ingenious scheme evolved by the Japanese is the use of the chrysalis or pupal stage of the silk worm after the silk is spun from the cocoons. Since the cocoons are boiled before spinning the chrysalids are dead. In order to make them attractive to the frogs, they must be given a movement. Wooden trays, similar to those described for minnows, are given a slow motion of a few inches back and forth by means of a water motor. The pupae are round, and due to the inertia of the shallow water (½ inch), roll back and forth in the trays, where they are greedily devoured by the frogs which mistake them for live insects.

The Ideal Frog Farm. In America and other countries where similar economic conditions prevail, because of the high cost of labor, and the relatively low cost of land suitable for frog farming, it is the author's belief that frog cultivation as intensive as followed in Japan cannot be made profitable as a general rule. Some compromise between the two extremes would be the ideal frog farm, but the degree of intensity decided upon, must depend upon all the circumstances in each particular case.

Importance of Shore-line. The first question asked by most prospective frog farmers is "How big a pond must I use for so many breeders, and how many young frogs can I expect to raise in it?" Well, as hinted in an earlier paragraph, growing frogs are not fish, and *do not live in ponds,* so why raise them in ponds at all? It is true that frogs lay their eggs in

ponds and their tadpoles live in water like fish. Furthermore, most of their food is found in ponds. They also usually spend their winters asleep under water in the bottom of ponds. But since our purpose is to raise frogs and not put them to sleep and since healthy, active growing frogs *live at the shoreline,* we must direct our main attention to the margin and not the pond proper.

Since the bigger the pond, the shorter the shorline in proportion to area, a large pond will rear less frogs per unit area than a small pond. This is one of the fundamental causes of failure of most frog farms when they begin to expand.

The problem then is to increase the shoreline without increasing the pond area. This can be done in several ways. One is to make the shoreline as irregular as possible, digging finger like bays and using the dirt to make long finger-like peninsulas. Another way is to create round or irregular islands. A horseshoe shaped unit or long narrow ponds might also be recommended. Each culturist must work out his own problem, especially if he wishes to utilize a pond, swamp, or marshy meadow already available.

If no such natural area is available and the whole project must be constructed, so much the better. The best plan that I can recommend is to construct a series of hills and ditches running preferably in a north-south direction, inside the selected area. The system, I believe, gives a far greater length of shore-line than any other shape of pond suitable for frog cultivation.

The other requirements of a frog culture project are essentially the same as for fish culture, viz. a soil capable of holding water, a cheap water supply of good quality, and good drainage.

Feeding. The young frogs may be fed upon insects attracted by light at night, upon live maggots, and upon flies attracted by various baits, in addition to the food items they secure naturally. Feeding the older frogs, however, is by far the most difficult problem in frog cultivation. Medium and large bullfrogs feed only upon large living objects and are seldom attracted by anything under ½ inch in length. Two hundred-watt non-frosted mazda lamps will attract many June beetles and medium sized moths. Arc lights will attract even larger insects and sometimes in very large quantities. For using a lamp, the early part of the night is best, and the hotter the night the better. Willow trees also attract large numbers of June beetles which later in the night drop to the

ground to lay their eggs and are taken by the frogs. Flower beds will attract butterflies and other day flying insects to the vicinity of the pens. The pond itself will also attract many other insects seeking water, and dragon flies go there to deposit their eggs. While all these things are helpful it does not provide the bulk of food necessary for rapid growth, and some bulky food must be provided.

Top Water Minnows. Gambusia or any other species of small fish which feed at the surface, if reared in abundance, will be taken by the frogs if the water at the shoreline is very shallow. They can be reared in the same ponds with the crayfish and tadpoles. It is useless to try to rear fish which do not feed at the top of the water or at the water's edge as the frogs cannot catch them. It is better to use that space for crayfish and tadpoles.

Ideal Foods. Experience has taught us that by far the best foods for half grown and large bullfrogs are pond or swamp crayfish and green frogs, as well as baby bullfrogs. These are all species which can be cultivated wherever bullfrogs will grow, and often in the same pens at the same time.

For the cultivation of the greenfrog, we recommend exactly similar conditions and pens as for the bullfrog, so that simplifies matters considerably. To insure a good crop of full-sized greenfrogs, bullfrogs must not be present as they will devour them. Greenfrog culture is also simpler than bullfrog culture, as they can be fed entirely upon insects, maggots and the like, until maturity.

The greenfrog grows rapidly, and if food is plentiful, will reach maturity within a year after transformation. As a food supply for bullfrogs it is not necessary to allow them to mature. A bullfrog pond may simply be stocked constantly from another pond with large greenfrog tadpoles, and the bullfrogs will devour them as fast as they transform and leave the water. Thus in from six months to a year, as abundant supply of wholesome bullfrog food will become available in virtually unlimited quantities.

For bullfrogs, pond crayfish are by far the most important most of the active season of the frogs. As crayfish are essentially shallow water and shoreline creatures, it is obvious that time on the bill of fare, serving as a food supply throughout to rear them successfully one must increase the shallow water area and the shoreline as well. Thus, they can be reared successfully in pens similar to those recommended for bullfrogs and greenfrogs and even at the same time. Unlike fish, crayfish cannot usually secure sufficient oxygen from the

water, and, especially when crowded, must have means of resting at the surface so that they can expose their gills to the air. For this reason it is best to provide a very gradual slope along the shores.

The best plan for a crayfish pond, as with a frog pond, is to construct a series of hills and furrows inside the pond area. The hills should reach a few inches above the water level when the pond is fuil. This system as already stated gives a far greater area of shorline than in an ordinary pond. Since as with frogs, the number of crayfish that can be reared in a given area is not proportional to the area, but to the extent of the shoreline, several times as many can be reared in the same areas by following this advice.

The hills should be planted profusely in willows to provide the proper shade at the shoreline. The roots of these provide excellent hiding places for young crayfish, and during the breeding season, the adults tunnel among them. Cypress are also desirable but take many years to grow.

In the submerged furrows between the hills, arrowheads should be planted in profusion. Other water plants will do, but arrowheads are one of the best crayfish food plants. When the young crayfish crop comes on in the spring, it can be noted by the muddy water, and by their cutting down the plants. It is now time to provide extra food in the way of fish, meat, plants of any kind, potato (raw or boiled) and any kind of table leavings. Tadpoles and crayfish will live together and fortunately both are scavengers and will feed on the same substances.

It is a good plan to have additional crayfish ponds as well as rear them in the same ponds with the frogs. Thus there will be a reserve supply of food always at hand. Crayfish can be secured by seining or netting, and the frog farm proper constantly re-stocked.

Plant Life. As a natural food supply and harborage for crayfish and tadpoles, as well as oxygenators, I believe the sagittarias are the most valuable of all plants to be cultivated by the frog farmer. In addition to these, some of the submerged aquatics, such as Potomogeton natans and Potomogeton pusillus, are valuable in the deeper areas.

SCREENING OF OPEN DIVERSIONS IN THE STATE OF WASHINGTON

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To those acquainted with fisheries conservation problems it is unnecessary to explain the need for screening of all open diversions from streams and lakes inhabited by fishes. In the State of Washington, under the direction of Mr. Charles R. Pollock, Supervisor of Fisheries, for the State of Washington, and the supervision of Mr. L. E. Mayhall, Superintendent of Hatcheries, work has been carried forward to perfect a revolving screen to meet the various screening problems.

In 1928, cooperating with Mr. C. A. Cobb, Manager of the Congdon Canal, the first successful revolving screen of the over-travel type was installed and experimented with. Careful check was made on the screen for two successive seasons, proving it to be effective. The initial cost was high and further designing was desirable to reduce the cost of manufacture. Since 1929, utilizing a new plan for manufacturing a total of fourteen screens have been installed by the ditch companies of the Dungeness district from the Dungeness River; Yelm district from the Nisqually River; and the China Irrigation district from the Mathow River.

The two principal considerations of any fish screen are the stopping of fish and the unimpeded flow of water; in addition initial cost and maintenance are important factors to be considered in the design. The over-travel screen as adopted by the Department of Fisheries and Game, State of Washington, fulfills these requirements.

To give an understanding of an over-travel screen a short description of its parts and action will be presented. The screen which holds back the fish and passes the debris is cylindrical in shape; the hollow cylinder is carried on a shaft horizontally across the ditch. The top of the screen drum moves with the current carrying the debris over the top. To revolve this drum a paddle wheel is used with an eccentric operating a ratchet drive. Seals are necessary to prevent passage of fish between either the side of the drum and the wall or the bottom of the drum and the floor of the ditch. When downstream migrants are stopped in a diversion any distance from the river they will not return upstream and if held in the ditch will be lost. A by-pass or return to the

main stream is provided, consisting of a hole in the wall near the bottom seal, at floor level.

During the investigation for the selection of a suitable screen, other types were considered. Most of the screens gave no thought to the returning of fish to the main stream, nor attention to the velocity of the water which directly affects fish life. Some attempted to pass heavy debris by arrangement to open the screen at intervals. To prevent the passage of fish during these intervals they depended upon frightening the fish away or utilizing some sort of temporary screen. However, the fish became accustomed to constant noise and passed through the openings or passed through before the temporary screen came into place. The over-travel screen, being sealed in, has no openings nor is any attempt made to frighten fish. Heavy debris is taken care of by rack bars as it is not a serious impediment to water flow.

Another type revolved under but was not successful as debris jammed under the drum. Further, it presented an opening in the area where the bulk of the fish lay. Screens received infrequent and often unskilled attention so a rugged construction of few parts is essential. The over-travel screen, as installed, has only two bearings and the eccentric to be lubricated: the drum is free from internal construction which would tend to collect debris and impede the flow and which is practically impossible to clean or repair. A flat screen is simple in construction but requires constant attention to keep it clean. In most streams at certain periods of the year twenty minutes would be sufficient to collect an impervious layer on a stationary screen.

The self-cleaning action of the over-travel screen is one of its best features as the action is positive and simple. The debris collects on the upstream side and is carried over the drum to the downstream side where the water passing through the screen washes it away. The efficiency of the over-travel screen was tested in the upper ditch from the Dungeness River where a by-pass trap was used. A weekly count was made of the fish trapped and at any shut down the ditch was checked below the screen. The number of fish trapped relative to the number found below indicates the high efficiency to be expected from these screens.

The equipment of a simple over-travel screen consists of the following: A proper concrete section, one or more cylindrical drums made of metal frame work and covered with a heavy screen, a current wheel installed below the drum with an eccentric and rod to roll the screen drum, proper

side and bottom seals and a fish by-pass or return ditch to the river. In established diversions generally the gradient allows for no extra head to be lost either in the drum or in generation of power. This means that the problem is one of using the ditch as is. In new diversions any construction calling for head above the necessary gradient increases the cost.

The problem of the design of each piece of equipment will be taken up in order.

Factors in Computing Size of Screen

The maximum flow in cubic feet per second must first be determined so that the size of the screen may be computed. Practice has established that an average section velocity of two feet per second is the maximum velocity at which a screen may be expected to give satisfactory service. This limit is not restricted by mechanical features but from the fact that small fish are unable to handle themselves in higher velocities and would be swept against the screen and drowned; there is a possibility, too, of damage by heavy drift in high velocity.

Using the average velocity of two feet per second and knowing the number of cubic feet per second the area can be obtained by simple division making proper allowances for all solid frame work. In ditches having velocities under this figure determine a reasonable average velocity to obtain the cross section. In normal water flow in ditches the average velocity would be computed from a summation of the velocities of the horizontal sections using the average vertical velocities determined by the typical flow curve. The velocities at the bottom are the least and that is where the fish naturally lie.

The problem might be attacked from another standpoint and that is to increase the size of the ditch to a point that would equal the loss of area due to the wire screen. However, this approach would not take into account the wide range of velocities in the various diversions. In a cylinder the actual area of screen is greater than a cross section, when designed for an average velocity of two feet per second. With this velocity there is no tendency for debris to drive into the screen meshes and so far no trouble has been encountered in passing over all floating debris of light character. Moss and algae which tend to cling have been successfully handled.

Locating the Screen in the Diversion

The placement of the screen is the next consideration. The diversion is examined to find a place which gives a proper depth, strength of bank construction and possible by-pass to river. It is not good practice to place the screen in front of the head gates as it is practically impossible to control the head due to flood conditions, or to protect the screen against heavy drifts. The screen cannot be placed in high velocity so placement directly back of the head gate is impracticable. There is always a possibility of an overflow at the screen through some unusual occurrence so it is good practice to place the screen at some point where a protective spill can be made without damage to property. The location should be downstream from any regulatory spill in order that the least amount of water be screened. There should be sufficient fall to the main stream to construct a by-pass for sand and gravel as well as fish. The by-pass is so important to the screen operation that care must be taken in consideration of the placement.

Preparation of the Section

Ten feet has been established as a maximum length of a screen unit. In the event that more than a single unit is installed stop planks should be provided so that any section may be shut off, in which case the section must be treated as a submerged tank and wall strength designed for the proper hydraulic pressure. In the analysis the stop planks lend no bracing so assume a cantilever wall. After determination of the size of screen or the number of units required the excavation is prepared and the forms built. The wall and floor slab of the usual section are six inches thick, all concrete work reinforced by half inch square whose placement depends upon the character of the ground. Toe piling may be used if the field examination warrants. Wing walls are built to a size necessary to protect the particular bank.

In ordinary diversions wooden side boards form the guide grooves for the screen bearings and carry the side seals; these planks are rough boards held in place by bolts set in the concrete walls. In the floor bolts are set to carry the frame work for the bottom seal, and bolts in the walls carry the paddle wheel bearings. Consideration must be given to the fluctuating water level and grooves left to carry splash boards in the rear of the screen. With these boards the water level can be maintained at the center of the drum or above.

This is desirable to give maximum efficiency in cleaning and to keep the screen bearing lubricated.

The Sealing of the Screen Drum

The side seals consist of two inch thin rubber belting mounted on shims of desired thickness. These shims bring the belting out so that the rim of the drum runs inside it but with no physical contact between seal and rim. The belt is notched on one side so a circle may be formed to fit as snugly as possible to the drum. The bottom seal is a five inch duty rubber belting mounted on a beveled 2 x 4 cut to fit snugly between the side seals filling up the two inch clearance between drum and floor.

The belt is mortised into two cross pieces spaced at quarters from the ends. These cross pieces are notched at each end to slip over the bolts previously set in the floor slab. The belt and 2 x 4 are spaced at about the center of these members. By means of the slots the bottom seal is adjusted; the frame may be pushed forward by loosening the bottom bolts.

The 2 x 4 carrying the belt is beveled so that the belt is about 15° from the vertical, giving contact with the screen more on the side, thus increasing the life of the belt, as light contact with the screen drum should be maintained. Owing to the angle of contact and the fact that fish lie perpendicularly any opening between the drum and seal caused by wear or high spots is not presented at full width; making this type of seal very effective. The eddy created by the bottom seal is an excellent place for fish to lie and for this reason the bypass should be near it as will be explained later on.

Construction of the Screen Drum

The necessary cross section has been determined and by allowing for six inches of free board on maximum height the diameter of the screen is obtained. The design of this drum has been divided into two classes, those four feet or less in diameter and those of diameters greater than four feet. The construction of drums four feet in diameter or less is as follows: A plate of light gauge metal is cut to proper diameter. Hand holes are cut out, their size relative to the diameter of the plate; these hand holes lighten the assembly and afford an opportunity to remove dents from the wire as well as facilitate construction.

A band support is provided for each two feet of width. This spacement of the bands is to eliminate as much sag in the

screen as is reasonable in construction. The center bands are 1¼ by ¼ flats rolled to shape and spot welded to the plate. Each plate is brazed to a hub drilled to slip over the shaft to be fastened by set screws. The end bands are formed by 1¼ x 1¼ x ¼ angles, rolled leg out forming a rim which provides the method of sealing the side.

The rim opposite from the by-pass opening is notched evenly to act as a ratchet. The reason for choosing the side opposite the by-pass opening is that the drop of the ratchet has a tendency to drive the fish temporarily away. The change for drums of over four feet is the substitution of spokes for the plate because plate material is expensive in large sizes. T's are used for the bands as angles cannot be rolled successfully with the leg in; further, the T's give better opportunity to fabricate.

The screen is fastened to the bands by means of ¼ inch flat head stove bolts, spaced six inches around the circumference. The length of the head of this type of bolt gives contact with the band, making it possible to draw the screen down tight. Where the longitudinal seam comes a light angle is brazed into place between the bands so the wire ends will join on the angle at the proper diameter. The ends of the screen are then brazed together. The screen chosen is of twelve gauge wire, three meshes to the inch, dip galvanized, the opening being 0.202 inches square. Care must be exercised in making the bands to see that the completed circles are within ⅛ plus or minus in diameter. This close a circle must be rolled to make sealing effective and reduce the wear due to high spots. In constructing the end rim it must be trued to prevent wobble.

Very small fish, such as newly hatched whitfish or humpback in the late Alevin stage might be swept through the mesh, but with a properly placed by-pass these fish would tend to take the larger opening if the velocity is correct. Furthermore, since the screen is cylindrical the opening of the mesh offered on a horizontal plane is not the full height of the flat area.

Design of the Shaft

The shaft is treated like a beam, disregarding the small torque or twist. The dead weight of the whole assembly is considered carried on the shaft, disregarding the effect of a hollow cylinder made by the screen. However, this anlysis would depend on the holding power of the single wire under the bolts which is indeterminate. The theorectical size of

shaft gained by the shaft formula is from one to two sizes larger than actual need, probably accountable from the factor of safety used for machinery shaftings. A reasonably smaller shaft is used and found satisfactory.

In large size screens hollow shafts reduce the weight and gain strength. This problem could be attacked from the angle that in case the screen becomes clogged the drum becomes a gate. The analysis of these stresses calls for sizes which run the costs up prohibitively. In most cases, before this condition could exist the low water would give warning and the trouble would be located before damage occurred. The hollow cylinder effect of the screen, although disregarded, does lend a factor of safety. In most large diversions, where the greatest danger lies, the water is generally checked so carefully that the stoppage would be noticed long before the head difference was serious.

Again, in many cases it is possible to protect by alarm systems. In the average diversions in the State of Washington it is found to be good practice to disregard any head difference in the screen drum design. The limit of ten feet was reached from consideration of the size of the shaft and the handling of the completed drum. The computation for the shaft size is based upon the moment due to the unifrom load of the shaft and concentrated loads of each supporting rim.

Taking a two foot increase in length ten feet for a medium size screen the moment in inch pounds increases rapidly. In choosing the shaft from a table based on the formula shaft diameter equals the cube root of 5.1 times the square root of M square plus T square divided by unit stress, and by using T as the smallest moment the size becomes correspondingly greater. The increase of size and weight is out of proportion to the advantages of a longer screen. The fact that the drum must be transported and placed in the section completely built necessitates having a size of drum which may be handled by block and tackle or simple levers. A bulky drum is awkward so this feature limits the drum length in many cases. It has been found desirable to remove the screens during the winter period if ice flows are encountered or for inspection and possible repairs. An overhead frame of proper clearance is installed to carry the block and tackle for handling the drum.

The By-pass

The by-pass has been discussed in relation to other parts of the screen but its importance has not been fully explained. Observations made of downstream migrants have shown that once they are trapped in a diversion any great distance from the river the fish will not return upstream. As has been previously explained screening at the head works is generally impossible, hence some method must be provided to return the fish to the river.

The by-pass opening into the ditch should be located so that fish can find same readily, in other words the longer they are trapped in front of the screen the greater the possibility that they may be lost. The opening of the by-pass into the ditch and its spacement have been experimented with. It was found that fish bunch above the screen when the opening is three feet ahead of the bottom seal and do not if the distance is cut down to a few inches.

The best vertical location was also determined, a weir pour was used, then an opening about center and finally at the bottom, finding the bottom opening most effective and the weir pour least effective. The screen stops sand and gravel and other bottom drift which must be taken care of. The by-pass may act as a gravel trap if a sloping trench is made in the bottom near the seal strip but care should be taken to get the proper fall into the river to prevent stoppage.

If the by-pass is of underground construction it should be of sufficient size to permit cleaning. If more than one screen unit is used the by-pass can be utilized in draining any one section to permit adjustment of the seals, etc., by using a common pipe and gates in each section. In some places it is hard to obtain water to run a by-pass and special care must then be taken to cut down the quantity of water; by use of a riser with a top pour and a method of periodical cleaning.

Power Drive

The power required to drive screens varies with the friction of the bottom seal. The amount of power available to drive the screen varies with the speed of the ditch and quantity of water. For the above reason no estimate has been made as to the exact power requirements. Reasonable judgment for the diameter of paddle wheel and width of paddles must be made, keeping in mind the speed necessary to revolve the screen.

The usual method of drive is a current wheel, but this method cannot be used when the average velocity of the sec-

tion is much less than one foot per second. The low water condition does not affect the drive as the use of the splash boards in the back of the screen to maintain head creates a fall which can be directed against the paddles to give the desired speed. In diversions where velocities fall below one foot per second a special means of obtaining power is necessary. The by-pass water can be used to drive an over shot wheel set below the ditch requires head, generally three feet is sufficient above high water. The current wheel gives the cheapest construction and is simple to operate. The paddle wheel shaft spans the ditch, running in metal bearings. The paddle wheel frame is made of angle irons bolted to hubs which are keyed to the shaft. The paddles are wood, bolted to the arms. Steel spokes are necessary as there is a rack due to the irregular velocities encountered by the paddles in making a complete turn. The shaft size may be determind from shaft formulas, using dead weights.

The paddle wheel shaft carries an eccentric which furnishes the motion for revolving the screen, or in case of an over shot wheel or other type of drive it is carried on a counter shaft. The eccentric is set so the rod may over travel the usual two inch notches, provided on the rim of the drum,—the ratchet system. The screen could be revolved by use of gears or chain but to obtain the same reduction as the ratchet system the cost is prohibitive. With either a chain or gear drive a more complicated section is required and a lubrication problem arises.

In the ratchet system the diameter of the paddle wheel with the diameter of the screen drum gives high mechanical advantage, as the screen is moved only about two inches for each revolution of the paddle wheel. High speed is not essential. Experience shows that a complete change of clean screen every four to ten minutes is sufficient. The area presented to the upstream side on which the debris impedes the water is about 0.4 the circumference, the back side is clean and need not be considered; further there is free board of six inches or more. This means that a complete revolution should take from ten to fifteen minutes. High speed only increases wear and is not essential.

The ratchet system gives high mechanical advantage and the greatest possible speed reduction more simply and cheaply than any other drive. The ratchet rod, due to its length, bends, tending to shorten the stroke, and should be heavy to eliminate as much of this bend as possible. To prevent roll

back a gravity catch is provided, mounted on a shaft set into the wall sufficiently back of the drum to give clearance when lifting or setting the drum in place. This catch is adjustable. The bearings for the paddle wheel shaft must be of the proper size made of any suitable metal as they are above the water and lubricated with soft grease. The screen drum bearings are of lignum vitae wood as it is successfully used with water lubrication; it is so universally used that its merits need not be discussed.

Accepted practice gives the allowable pressure of 355 pounds per square inch of projected area. To obtain this area it is necessary to figure the total weight of the screen drum. The bearing is fashioned by boring the proper size hole in a square piece using the computed area to obtain the necessary width. The square shape permits the use of guide grooves making either the placement or the removal of the drum a direct lift from the section. This is a simple scheme as there are no bolts to unfasten or equipment to remove.

In the design of a screen the shop problems involved and the machines necessary for fabrication must be considered as manufacture cannot very well be limited to one shop owing to the problems of transportation. Therefore, local standards must be considered as it would be unwise to standardize on any materials which cannot be obtained locally or which are specially manufactured articles. The past work of these screens has shown that this type of mechanical screen, when designed properly for capacity of ditch, velocity and mechanical construction gives highly satisfactory results. In this state a surface diversion screening problem has yet to arise which cannot be solved by the mechanical revolving screen.

(Detailed blueprints may be obtained from the State Supervisor of Fisheries, Seattle, Wash.)

APPENDIX

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AMERICAN FISHERIES SOCIETY

Organized 1870

CERTIFICATE OF INCORPORATION

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certify in writing;

1. That the name of the Society is the American Fisheries Society.

2. That the term for which it is organized is nine hundred and ninety-nine years.

3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(a) To acquire, hold and convey real estate and other property, and to establish general and special funds.

(b) To hold meetings.

(c) To publish and distribute documents.

(d) To conduct lectures.

(e) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.

(f) To acquire and maintain a library.

(g) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

SEYMOUR BOWER (Seal)
THEODORE GILL (Seal)
WILLIAM E. MEEHAN (Seal)
THEODORE S. PALMER (Seal)
BERTRAND H. ROBERTS (Seal)
HUGH M. SMITH (Seal)
RICHARD SYLVESTER (Seal)

Recorded April 16, 1911.

CONSTITUTION AND BY-LAWS

(As amended to date)

ARTICLE I

Name and Object

The name of this Society shall be American Fisheries Society. Its object shall be to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; the uniting and encouraging of all interests of fish culture and the fisheries, and the treatment of all questions regarding fish, of a scientific and economic character.

ARTICLE II

Membership

Active Members.—Any person may upon a two-thirds vote of the members present at any regular annual meeting and upon the payment of one year's dues become an active member of this Society.

The annual dues of active members shall be three ($3.00) dollars per year, payable in advance. In case of non-payment of dues for two consecutive years, notice shall be given by the Treasurer in writing, and such member remaining delinquent after one month from the date of such notice, his name shall be dropped from the roll of the Society. Such delinquent member, having been dropped for non-payment of dues, shall be ineligible for election as a new member for a period of two years, except upon payment of arrears.

Club Members.—Any sporting or fishing club or society, or any firm or corporation, upon a two-thirds vote of the members present at any regular annual meeting and upon the payment of one year's dues, may become a club member of this Society. The annual dues of club members shall be five ($5.00) dollars per year.

Libraries.—Libraries shall be admitted to membership upon application and the payment of one year's dues. The annual dues for libraries shall be three ($3.00) dollars per year.

State Memberships.—Any State, Provincial or Federal Department of the United States, Canada or Mexico may, upon application and the payment of one year's dues become a State member of this Society. The annual dues for State memberships shall be ten ($10.00) dollars per year.

Life Memberships.—Any person may, upon a two-thirds vote of the members present at any regular annual meeting and the payment of fifty ($50.00) dollars become a life member of this Society and shall

thereafter be exempt from payment of annual dues. The Secretary and Treasurer of the Society are hereby authorized to transfer members from the active list to the list of life members provided that no member shall be so transferred unless he shall make request for such transfer and shall have paid dues as an active member of the Society for at least twenty-five years.

Patrons.—Any person, society, club, firm or corporation, on approval of the Executive Committee and the payment of fifty ($50.00) dollars or more, may become a patron of this Society with all the privileges of a life member, and shall be listed in all the published membership lists of the Society.

Honorary and Coresponding Members.—Any person may be made an honorary or corresponding member upon a two-thirds vote of the members present at any regular annual meeting of the Society. The President (by name) of the United States, the Governors (by name) of the several States and the Secretary of Commerce of the United States (by name) shall be honorary members of the Society.

Election of Members Betwen Annual Meetings.—The President, Secretary and Treasurer of the Society are hereby authorized during the time intervening between annual meetings, to receive and act upon all applications for individual and club memberships. A majority of such committee shall decide upon the acceptance of such applications.

Voting.—Active members and life members only shall have the right to vote at regular or special meetings of the Society. Fifteen voting members shall constitute a quorum for the transaction of business.

ARTICLE III

Funds

Current Fund.—All moneys received from the payment of dues of active members, club members, libraries, life members, State members, sale of Transactions, contributions thereto, and from any miscellaneous sources, shall be credited to the Current Fund of the Society and shall be paid out only on vouchers regularly approved by the President and Secretary.

Permanent Fund.—The President, Secretary and Treasurer shall be the Trustees of the Permanent Fund. All moneys received from patrons, bequests and contributions thereto shall be credited to the Permanent Fund of the Society. Such fund shall be invested by the Treasurer in such manner as may be approved by the trustees of such fund. The members of the Society shall, at each annual meeting, determine the disposition of interest accruing from such investments.

ARTICLE IV

Officers

The officers of this Society shall be a President and a Vice-President, who shall be ineligible for election to the same office until a year after the expiration of their term; a Secretary, a Treasurer, a Librarian, and an Executive Committee of seven, which, with the officers before named shall form a council and transact such business as may be necessary when the Society is not in session—four to constitute a quorum.

In addition to the officers above named there shall be elected annually five Vice-Presidents who shall be in charge of the following five divisions or sections:

1. Fish Culture.
2. Commercial Fishing.
3. Aquatic Biology and Physics.
4. Angling.
5. Protection and Legislation.

No officer of this Society shall receive any salary or compensation for his services and no allowances shall be made for clerical services except by vote of the Society at regular annual meetings.

Duties of Officers.—The President shall preside at the annual and all special meetings of the Society, shall be ex-officio chairman of the Council of the Society, and shall exercise general supervision over the affairs of the Society.

The Vice-President shall act in the place of the President in case of absence or inability of the latter to serve.

The Secretary shall keep the records of the Society, attend to the publication and distribution of its Transactions, attend to its correspondence, promote its membership, and arrange for annual and special meetings.

The Treasurer shall receive and collect all dues and other income of the Society, shall have the custody of its funds and pay all claims which have been duly approved. The Treasurer shall furnish a bond in the sum of one thousand ($1,000) dollars to be approved by the Executive Committee and to be paid for by the Society.

The Librarian shall have the custody of the library of the Society, including its permanent records and printed Transactions, and shall have charge of the sale of surplus copies of such Transactions. Other officers shall perform such duties as shall be assigned them by the President.

ARTICLE V

Meetings

The regular meeting of the Society shall be held once a year, the time and place being decided upon at the previous meeting, or, in default of such action, by the Executive Committee.

ARTICLE VI

Order of Business

1. Call to order by the President.
2. Roll call of members.
3. Applications for memberships.
4. Reports of officers.
   a. President.
   b. Secretary.
   c. Treasurer.
   d. Vice-Presidents of Divisions.
   e. Standing Committees.
5. Committees appointed by the President.
   a. Committee of five on nomination of officers for ensuing year.
   b. Committee of three on time and place of next meeting.
   c. Auditing committee of three.
   d. Committee of three on program.
   e. Committee of three on publication.
   f. Committee of three on publicity.
6. Reading of papers and discussions of same.
   (*Note*—In the reading of papers preference shall be given to the members present.)
7. Miscellaneous business.
8. Adjournment.

ARTICLE VII

Changing the Constitution

The Constitution of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least fifteen members are present at said regular meeting.

AMERICAN FISHERIES SOCIETY
LIST OF MEMBERS, 1931-32

(Showing Year of Election to Membership)

HONORARY MEMBERS

The President of the United States.
The Secretary of Commerce of the United States.
The Governors of the several States.
'08 Antipa, Prof. Gregoire, Inspector-General of Fisheries, Bucharest, Roumania.
'06 Besana, Giuseppe, Lombardy Fisheries Society, Via Rugabello 19, Milan, Italy.
'09 Blue Ridge Rod and Gun Club, Harper's Ferry, W. Va.
'93 Borodin, Nicolas, Museum of Comparative Zoology, Harvard University, Cambridge, Mass.
'04 Denbigh, Lord, London, England.
'04 Kishinouye, Dr. K., Imperial University, Tokyo, Japan.
'17 Mercier, Honoré, Minister of Lands and Forests, Quebec, Canada.
'09 Nagel, Hon. Chas., St. Louis, Mo.
'08 Nordqvist, Dr. Oscar Fritjof, Superintendent of Fisheries, Lund, Sweden.
'06 Perrier, Prof. Edmond, Director, Museum of Natural History, Paris, France.

CORRESPONDING MEMBERS

'22 Director, All-Russian Agricultural Museum, Fontanka 10, Leningrad Russia.
'22 Director of Fisheries (British Malay), Singapore, Straits Settlements.
'22 Library, National Museum of Natural History, Paris, France.
'10 Stead, David G., Fisheries Department, Sydney, New South Wales, Australia.

PATRONS

'14 Alaska Packers Associations, San Francisco, Calif.
'15 Allen, Henry F. (Agent Crown Mills), 210 California St., San Francisco, Calif.
'15 American Biscuit Co., 815 Battery St., San Francisco, Calif.
'15 American Can Co., Mills Building, San Francisco, Calif.
'15 Armour & Co., Battery and Union Sts., San Francisco, Calif.
'15 Armsby, J. K., Company, San Francisco, Calif.
'15 Atlas Gas Engine Co., Inc., Foot of 22nd Avenue, Oakland, Calif.
'15 Balfour, Guthrie & Co., 350 California St., San Francisco, Calif.

'15 Bank of California, N. A., California and Sansome Sts., San Francisco, Calif.
'15 Bloedel-Donovan Lumber Mills, Bellingham, Wash.
'15 Bond and Goodwin, 485 California St., San Francisco, Calif.
'15 Burpee and Letson, Ltd., South Bellingham, Wash.
'15 California Barrel Co., 22d and Illinois Sts., San Francisco, Calif.
'15 California Door Co., 43 Main St., San Francisco, Calif.
'15 California Stevedore and Ballast Co., Inc., 210 California St., San Francisco, Calif.
'15 California Wire Cloth Company, San Francisco, Calif.
'15 Caswell, Geo. W., Co., Inc., 503-4 Folsom St., San Francisco, Calif.
'15 Clinch, C. G., & Co., Inc., 144 Davis St., San Francisco, Calif.
'15 Coffin-Redington Co., 35-45 Second St., San Francisco, Calif.
'15 Columbia River Packers Association, Astoria, Ore.
'15 Crane Co. (C. W. Weld, Mgr.), 301 Brannon St., San Francisco, Calif.
'15 Dodge, Sweeney & Co., 36-48 Spear St., San Francisco, Calif.
'15 First National Bank of Bellingham, Bellingham, Wash.
'15 Fuller, W. P., & Co., 301 Mission St., San Francisco, Calif.
'15 Grays Harbor Commercial Co., Foot of 3rd St., San Francisco, Calif.
'15 Hendry, C. J., 46 Clay St., San Francisco, Calif.
'15 Jones-Thierbach Co., The, Battery and Merchant Sts., San Francisco, Calif.
'15 Knapp, The Fred H., Co., Arcade-Maryland Casualty Building, Baltimore, Md.
'15 Linen Thread Co., The, (W. A. Barbour, Mgr.), 443 Mission St., San Francisco, Calif.
'15 Mattlage, Chas. F., Company, 335 Greenwich St., New York, N. Y.
'15 Morrison Mill Co., Inc., Bellingham, Wash.
'15 Morse Hardware Co., Inc., 1025 Elk St., Bellingham, Wash.
'15 Nauman, C., & Co., 501-3 Sansome St., San Francisco, Calif.
'15 Pacific Hardware and Steel Co., 7th and Townsend Sts., San Francisco, Calif.
'15 Pacific States Electric Co., 575 Mission St., San Francisco, Calif.
'15 Phillips Sheet and Tin Plate Co., Weirton, W. Va.
'15 Pope and Talbot, Foot of 3rd St., San Francisco, Calif.
'15 Puget Sound Navigation Co., Seattle, Wash.
'15 Ray, W. S., Mfg. Co., Inc., 216 Market St., San Francisco, Calif.
'15 Schmidt Lithograph Co., 2d and Bryant Sts., San Francisco, Calif.
'15 Schwabacher-Frey Stationery Co., 609-11 Market St., San Francisco, Calif.
'15 Ship Owners' and Merchants' Tug Boat Co., Foot of Green St., San Francisco, Calif.
'15 Sherwin-Williams Co., The, 454 Second St., San Francisco, Calif.
'15 Smith Cannery Machine Co., 2423 South First Avenue, Seattle, Wash.

'15 Standard Gas Engine Co., Dennison and King Sts., Oakland, Calif.
'15 Standard Oil Co. of California, Standard Oil Building, San Francisco, Calif.
'15 U. S. Rubber Co. of Califorina (W. D. Rigdon, Mgr.), 50-60 Fremont St., San Francisco, Calif.
'15 U. S. Steel Products Co., Rialto Building, San Francisco, Calif.
'15 Wells Fargo National Bank of San Francisco, Montgomery and Market Sts., San Francisco, Calif.
'15 Western Meat Co., 6th and Townsend Sts., San Francisco, Calif.
'15 White Bros., 5th and Brannon Sts., San Francisco, Calif.

ACTIVE MEMBERS

'16 Adams, Dr. Charles C., State Museum, Univ. of the State of N. Y., Albany, N. Y.
'13 Adams, William C., Dept. of Conservation, Albany, N. Y.
'29 Ainsworth, A. L., Tuxedo Fisheries, Tuxedo Park, N. Y.
'20 Albert, W. E., State Fish and Game Warden, Des Moines, Iowa.
'31 Aldrich, A. D., 2879 East Archer, Tulsa, Okla.
'31 Allen, Walter M., U. S. Bureau of Fisheries, La Crosse, Wis.
'29 Allen, William Ray., Dept. of Zoology, University of Kentucky, Lexington, Ky.
'29 Allyn, Leon C., 67 Park Avenue, Rochester, N. Y.
'26 Alm, Dr. Gunnar, Commissioner of Fresh Water Fisheries, Lantbruksstyrelsen, Stockholm, Sweden.
'23 Amsler, Guy, Department of Fish and Game, Little Rock, Ark.
'08 Anderson, August J., Box 704, Marquette, Mich.
'24 Annin, Harry K., Spring Street, Caledonia, N. Y.
'14 Annin, Howard, Van Cortland Ave., Ossining, N. Y.
'26 Armstrong, Hon. Harry M., Commissioner Fish and Game, 452 Montgomery St., Jersey City, N. J.
'25 Atherton, Giles, Citizens State Bank, El Dorado, Kansas.
'29 Atkinson, C. J., 93 Grove St., Ottawa, Ont., Can.
'28 Avery, E. S., Elma, Wash.
'01 Babcock, John P., Provincial Fisheries Department, Victoria, B. C., Canada.
'27 Baker, Clarence, 2 South Carroll St., Madison, Wis.
'29 Baker, Dr. Davis, Insurance Bldg., Glens Falls, N. Y.
'15 Balch, Howard K., 156 West Austin Ave., Chicago, Ill.
'01 Baldwin, O. N., U. S. Bureau of Fisheries, San Marcos, Tex.
'98 Ball, E. M., U. S. Bureau of Fisheries, Washington, D. C.
'23 Bangham, Dr. Ralph V., Wooster College, Wooster, Ohio.
'28 Banner, James R., U. S. Bureau of Fisheries, Washington, D. C.
'20 Barbour, F. K., Linen Thread Co., 200 Hudson St., New York City, N. Y.

'05 Barbour, Prof. Thomas, Museum of Comparative Zoology, Cambridge, Mass.
'26 Barnes, J. Sanford, 52 Vanderbilt Ave., New York, N. Y.
'22-'29 Bayne, Bliss, Supt., Hyattville State Fish Hatchery, Hyattville, Wyo.
'28 Beakbane, Alfred Bernard, 31 Thompson Ave., Glens Falls, N. Y.
'29 Beans, Thomas A., Crawford, Neb.
'00 Beeman, Henry W., New Preston, Conn.
'28 Bell, F. Howard, International Fisheries Commission, University of Washington, Seattle, Wash.
'18 Bellisle, J. A., Inspector General of Fisheries and Game, Quebec, Canada.
'80 Belmont, Perry, 1618 New Hampshire Ave., Washington, D. C.
'28 Bengard, F. A., Springerville, Ariz.
'25 Bengard, John P., Valley Ranch, New Mexico.
'28 Benjamin, S. H., P. O. Box 507, Brevard, N. C.
'29 Benson, John W., Rolette, N. D.
'13 Berg, George J., Indiana Fish Commission, Indianapolis, Ind.
'27 Biddle, Spencer, R. F. D. No. 1, Vancouver, Wash.
'27 Birdseye, Clarence, General Seafoods Corporation, Gloucester, Mass.
'28 Bishop, M. S., R. F. D. No. 2, Iroquois Trout Hatchery, Glens Falls, N. Y.
'24 Bitzer, Ralph, Montague, Mass.
'24 Blanchard, Charles, State Fish Hatchery, Unionville, Conn.
'25 Blankenship, Dr. E. L., Crystal Springs Trout Farm, Cassville, Mo.
'20 Bonner, Albert E., Coopersville, Mich.
'26 Borcea, Dr. Jean, Univ. of Jassy, Jassy, Roumania.
'30 Borger, Garrison, Brookhaven, N. Y.
'25 Borger, Samuel I., Brookhaven, N. Y.
'27 Boschen, W. B., 6 Lincoln Place, Freehold, N. J.
'30 Bosdeck, Ed., State Fish Hatchery, Route 11, Defiance, Ohio.
'25 Bottler, P. G., State Fish Hatchery, Emigrant, Montana.
'00 Bower, Ward T., U. S. Bureau of Fisheries, Washington, D. C.
'28 Bowlby, H. L., Appleton, Wis.
'30 Bowling, T. C., Pryor, Okla.
'30 Branion, Hugh D., Dept. of Biochemistry, University of Toronto, Toronto, Can.
'20 Breder, C. M., Jr., New York Aquarium, New York City, N. Y.
'26 Brenard, Thomas L., Care of Martin Fish Co., Atchafalaya, La.
'28 Brittain, William H., 8905 Colesville Pike, Silver Springs, Md.
'27 Brown, C. A., Hartwood, Sullivan Co., N. Y.
'16 Brown, Dell., U. S. Bureau of Fisheries, Lonoke, Ark.
'26 Brown, George E., Graybar Electric Co., Inc., 508 York Ave., S. Minneapolis, Minn.

'30 Brown, James, Commissioner of Fish and Game, Montpelier, Vt.
'28 Brunell, Gustav, Director del Laboratorio Centrale d'Idrobiologia, Piazza Borghese, 91, Rome, Italy.
'20 Buller, C. R., Pleasant Mount, Wayne County, Penn.
'28 Bunch, W. C., Bureau of Fisheries, Edenton, N. C.
'29 Burke, Dr. Edgar, Jersey City Hospital, Jersey City, N. J.
'17 Burkhart, Joe, Big Rock Creek Trout Club, St. Croix Falls, Wis.
'07 Burnham, Charles W., U. S. Bureau of Fisheries, Louisville, Ky.
'28 Burnham, Edwin K., Bureau of Fisheries, Washington, D. C.
'31 Burr, J. G., Game, Fish and Oyster Commission, Austin, Tex.
'28 Butler, Edward C., Box 36 B. B. Station, Boston, Mass.
'30 Butler, George Edward, Winnipegosia, Man., Canada.
'29 Butler, W. W., 621 Craig St., W., Montreal, Que., Canada.
'27 Byers, A. F., 1226 University St.. Montreal. Que.. Can.
'27 Cable, Louella E., U. S. Bureau of Fisheries, Washington, D. C.
'30 Candee, C. N., 47 Yonge St., Toronto, Canada
'28 Carlson, Ray A., Box 275, St. Croix Falls, Wis.
'23 Catt, James, District Inspector of Hatcheries, Customs House, St. John, N. B., Canada.
'07 Catte, Eugene, Catte Fish Hatchery, Langdon, Kansas.
'28 Cayon, H. T., Deer Harbor, Wash.
'18 Chamberlain, Thomas Knight, 7 Willis Ave., Columbia, Mo.
'29 Churchill, H. A., Sheridan, Wyo.
'29 Chute, Walter H., Director, John G. Shedd Aquarium, Grant Park, Chicago, Ill.
'29 Clapp, Alva, Pratt, Kan.
'21 Clemens, Dr. Wilbert A., Pacific Biological Station, Nanaimo, B. C., Canada.
'00 Cobb, Eben W., R. F. D., Farmington, Conn.
'29 Cokeley, H. A., Crawford, Neb.
'04 Coker, Dr. Robert E., Univ. of North Carolina, Chapel Hill, N. C.
'26 Comee, Joseph F., People's Gas Bldg., Chicago, Ill.
'26 Connett, Eugene V., 3rd, 170 Turrell Ave., S. Orange, N. J.
'29 Conway, W. P., 140 Broadway, New York, N. Y.
'28 Cook, A. B., Jr., Field Supt. of Fisheries, Ionia, Mich.
'22 Cook, Frank, Laramie State Fish Hatchery, Laramie, Wyo.
'17 Cook, Ward A., U. S. Bureau of Fisheries, Duluth, Minn.
'24 Coolidge, Charles A., 122 Ames Building, Boston, Mass.
'27 Coristine, Charles G., 11 Belvedere Road, Westmount, Montreal, Que., Canada.
'24 Corson, Robert H., 2814 Boulevard, Jersey City, N. J.
'18 Coykendall, Edward, 156 West Chestnut St., Kingston, N. Y.
'30 Craig, Charles, Dept. of Conservation, Lansing, Mich.
'13 Crandall, A. J., Ashaway Line & Twine Mfg. Co., Ashaway, R. I.
'11 Crasser, Hugo, U. S. Bureau of Fisheries, Yellowstone Park, Wyo.

'31 Crosby, Caroline M., 2105 First Ave., South, Minneapolis, Minn.
'28 Crosby, Col. W. W., Box 232, Coronado, Cal.
'30 Crowell, Mary, Shortsville, N. Y.
'25 Cuenin, J. P., San Francisco Examiner, San Francisco, Calif.
'08 Culler, C. F., U. S. Bureau of Fisheries, La Crosse, Wis.
'28 Cumings, Ed., Care Cumings Brothers, 901 Saginaw St., Flint, Mich.
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